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The role of agentic AI in shaping a smart future: A systematic review

Soodeh Hosseini [a,*], Hossein Seilani [b]

[a] Department of Computer Science, Faculty of Mathematics and Computer, Shahid Bahonar University of Kerman, Kerman, Iran
[b] School of Computer Engineering, Bahmanyar University of Kerman, Kerman, Iran

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ABSTRACT

Artificial intelligence (AI), particularly Agentic AI, is increasingly critical for addressing the demand for speed, efficiency, and customer focus in modern organizations. However, the rapid evolution of Agentic AI, including Generative AI (GenAI) agents, has outpaced a cohesive understanding of its applications, challenges, and strategic implications. This narrative review explores the role of Agentic AI in shaping an intelligent future, focusing on its key attributes—autonomy, reactivity, proactivity, and learning ability—and its potential to transform organizational performance. We identify a research gap in synthesizing the diverse capabilities of Agentic AI (e.g., multimodal processing, hierarchical architectures, and machine learning outsourcing) and providing actionable strategies for adoption. The paper examines how Agentic AI enables autonomous decision-making, automates processes, and enhances efficiency through tools like LangChain, CrewAI, AutoGen, and AutoGPT. It highlights the transition from assisted ("Copilot") to autonomous ("Autopilot") models and the importance of hierarchical agent structures for system coordination. Key contributions include a framework for organizations to formulate GenAI strategies, addressing business needs, tool selection, human resource training, and risk management. Findings reveal that Agentic AI significantly improves productivity, reduces costs, and drives innovation, though challenges such as privacy, security, and ethical concerns remain. Future research should focus on industry-specific case studies to deepen understanding, explore the ethical and social impacts (e.g., privacy, data security, labor market effects), and investigate the integration of Agentic AI with emerging technologies like quantum computing. This review provides a foundation for researchers and practitioners to leverage Agentic AI effectively while addressing its limitations and opportunities.

1. Introduction

Artificial Intelligence (AI) has evolved from being a mere computational tool to a transformative force that is reshaping industries, economies, and societies. AI is no longer limited to executing predefined tasks; rather, it now exhibits autonomous decision-making capabilities, adaptability, and goal-directed behavior. The integration of AI into various domains has led to increased efficiency, speed, and automation, driving the rapid adoption of AI-powered solutions by organizations seeking competitive advantages [1].

However, conventional AI models are typically designed for specific tasks and lack the autonomy to adapt dynamically to complex environments. This limitation has spurred interest in a new paradigm known as **Agentic AI**—a category of AI systems capable of independently making decisions, interacting with their environment, and optimizing processes without direct human intervention. Agentic AI represents a significant advancement over traditional AI agents by incorporating features such as self-learning, real-time adaptability, and multi-agent collaboration. Despite its potential, a comprehensive review of Agentic AI's role, applications, and challenges remains absent in current literature. This paper aims to bridge this gap by providing a detailed analysis of Agentic AI, its implications for a **Smart Future**, and the critical challenges associated with its adoption.

A **Smart Future** refers to an era where AI-driven automation, intelligence augmentation, and autonomous decision-making systems contribute to optimized operations in various sectors, such as healthcare, transportation, finance, and energy. By leveraging Agentic AI, businesses and governments can enhance efficiency, reduce operational costs, and improve service delivery. However, this transition also raises significant concerns regarding ethical AI deployment, data security, and workforce displacement. Understanding these challenges is crucial for ensuring responsible AI adoption.

This article is structured as follows: Section 2 provides an overview of AI advancements and current technological challenges. Section 3

* Corresponding author.
E-mail addresses: so_hosseini@uk.ac.ir (S. Hosseini), h.seilany@gmail.com (H. Seilani).

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delves into the concept of **Agentic AI**, discussing its fundamental principles and impact on productivity, competitiveness, and innovation. Section 4 examines the hierarchical structure of Agentic AI systems, while Section 5 explores their business imperatives. The **evolution of Agentic AI** is discussed in Section 6, followed by Section 7, which covers its applications in outsourcing and AI services. Section 8 reviews the available tools and solutions that facilitate the development of Agentic AI. Section 9 outlines strategies for effectively leveraging Agentic AI while addressing its challenges. Finally, Section 10 presents conclusions and future research directions.

1.1. Agent-Based Artificial Intelligence (agentic AI)

Agentic AI refers to AI systems that exhibit **autonomous decision-making, goal-oriented behavior, and continuous learning** while interacting with dynamic environments. Unlike traditional AI, which often relies on human intervention or pre-programmed instructions, Agentic AI adapts based on real-time data and evolving objectives. These intelligent agents leverage machine learning, reinforcement learning, and multi-agent coordination to perform tasks efficiently [2].

1.1.1. Applications of agentic AI

- **Energy**: Optimizes energy consumption, predicts demand, and enhances the efficiency of renewable resources using historical data and weather conditions.
- **Transportation**: Improves route planning, reduces delivery times, and enhances supply chain logistics.
- **Healthcare**: Aids in medical diagnosis, personalized treatment plans, and patient data management.
- **Finance**: Analyzes market trends, assesses investment risks, and optimizes financial decision-making.

Agentic AI has the potential to **revolutionize industries** by offering improved decision-making capabilities, efficiency, and adaptability. However, its adoption must be accompanied by strategies to mitigate associated risks.

1.2. Key aspects of artificial intelligence

Despite its advantages, Agentic AI presents **several challenges** that must be addressed to ensure ethical and secure implementation.

- **Data Security & Privacy**: AI systems process vast amounts of sensitive data, making them vulnerable to breaches. Organizations must enforce stringent data protection policies and comply with legal frameworks [3].
- **Ethical & Regulatory Concerns**: Autonomous AI decisions can have unintended consequences, necessitating transparent AI governance models and ethical AI principles.
- **Workforce Transformation**: Automation raises concerns about job displacement, requiring proactive workforce reskilling initiatives and AI-human collaboration strategies.

To address these challenges, organizations must adopt the following strategies.

- **Employee Training**: Upskilling programs to prepare employees for AI-integrated workflows.
- **Robust AI Governance**: Developing policies to ensure transparency, fairness, and accountability in AI decision-making.
- **Regulatory Compliance**: Aligning AI deployment with international laws and ethical AI guidelines [4,5].

Fig. 1 is a visual representation of the core characteristics or capabilities that define Agentic AI, presented as a central hub surrounded by six interconnected bubbles. The central circle, labeled “Key aspects of Agentic AI,” serves as the focal point, with arrows connecting it to the following six key aspects, arranged in a circular layout.

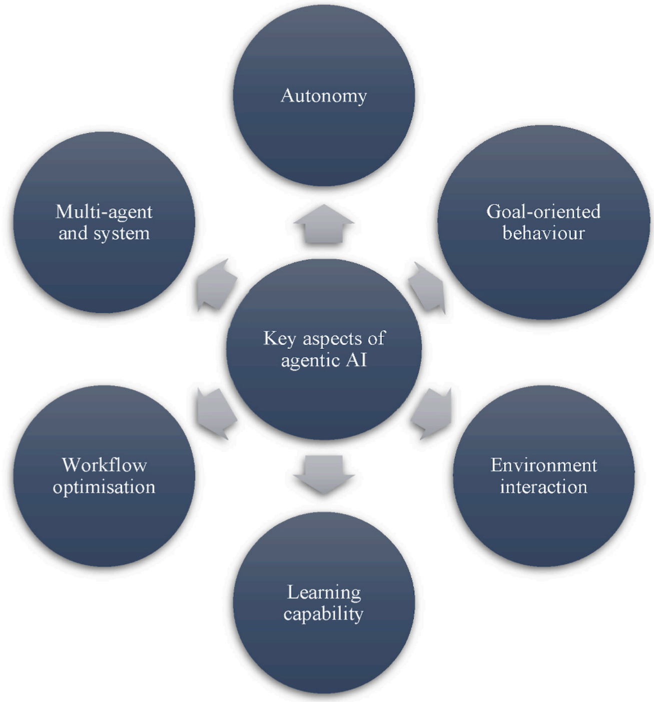

Fig. 1. Key aspects of artificial intelligence.

1. **Autonomy**: This aspect highlights Agentic AI’s ability to operate independently, making decisions, and taking actions without direct human intervention. It reflects the system’s capacity to use planning, learning, and environmental data to perform complex tasks autonomously.
2. **Goal-oriented behavior**: This indicates that Agentic AI is designed to pursue specific objectives and optimize its actions to achieve desired outcomes, such as minimizing costs in transportation or maximizing efficiency in energy systems.
3. **Environmental interaction**: This capability allows Agentic AI to perceive and adapt to changes in its surroundings, enabling it to function effectively in dynamic and complex real-world scenarios, such as adjusting logistics in response to traffic conditions.
4. **Learning capability**: This refers to Agentic AI’s ability to improve its performance over time through machine learning or reinforcement learning, leveraging past experiences to refine decision-making and achieve better results.
5. **Workflow optimization**: This aspect emphasizes how Agentic AI enhances business processes by integrating language understanding, reasoning, planning, and decision-making, leading to improved resource allocation, communication, collaboration, and automation opportunities.
6. **Multi-agent systems**: This highlights Agentic AI’s ability to facilitate communication and collaboration among multiple agents, enabling the creation of complex workflows and integration with other systems or tools (e.g., email, code execution, search engines) to perform diverse tasks [6,7].

Fig. 1 uses a circular, interconnected design with arrows to suggest that these aspects are interdependent and collectively define the essence of Agentic AI. The accompanying text in the image, “By implementing these measures, organizations can fully harness the potential of Agentic AI while mitigating its risks, thereby paving the way for a responsible AI-driven future," underscores the practical implications of these capabilities for organizations, emphasizing both opportunities and challenges.

Artificial Intelligence (AI) has transformed industries, but a distinct and emerging paradigm—Agentic AI—stands out for its potential to shape a "Smart Future": interconnected, efficient, and adaptive socio-technical ecosystems. Agentic AI is defined as AI systems that autonomously pursue specific objectives, optimize actions to achieve desired outcomes, and adapt dynamically to complex environments, distinguishing it from standard AI agents, which typically operate reactively or follow predefined rules. For instance, in the transportation sector, Agentic AI can optimize routes to reduce operational costs by up to 15 % while enabling companies to respond rapidly to customer demands, highlighting its transformative role across industries like energy, medicine, and investment [8].

Several critical aspects define the operation of **Agentic AI**, allowing it to function effectively across various domains. These aspects are summarized in Table 1.

2. Evolution of multimodal agents of generative artificial intelligence

Generative AI demonstrates a remarkable amount of evolution in the field of artificial intelligence. Much work started with simple rule-based systems designed to address some simple tasks, Over time, these evolved into more complex, even multimodal agents, which can process and integrate information from various representations including, but not limited to, text, images, audio, and video. These multimodal capabilities enable AI agents to understand information, reason over it, and interact much like humans do, furthering their effectiveness and flexibility in solving a wide array of business problems. The generative AI multimodal agents are not restricted to processing textual data; they are also used in the analysis of images, audio, and video. For example in the medical industry, such analyze CT scan images to identify diseases. They can also analyze images from the cameras of autonomous vehicles in transportation to enhance safety and efficiency. With this capability, generative AI agents have wide applications in medical, transportation, sales, and marketing industries [15]. However, there are challenges that emanate from the adoption of multimodal generative AI agents, such as data security, privacy concerns, and impacts on human resources. As a result, organizations must to have effective mechanisms to integrate the technology into their operations with a view to maximizing its benefits while mitigating risks.

This can lead to the design of systems that will someday be naturally and conceptually interactive with humans, increasing efficiency and productivity in various areas of human life, such as education, medicine, business, and even the arts. Therefore, based on this outcome, multi-purpose productive AI represents instruments of process automation and optimization. Moreover, they can even be considered the creative partners of humans within various creation and innovation processes.

The field of generative artificial intelligence (AI) has witnessed rapid and transformative evolution, transitioning from simple rule-based systems to highly sophisticated multimodal agents. These agents can process and integrate information from diverse representations, including text, images, audio, and video. Such capabilities enable AI systems to interact naturally with humans, reason effectively over multimodal data, and enhance problem-solving capabilities across various industries, including healthcare, autonomous transportation, and digital marketing.

The evolution of multimodal agents is closely tied to key breakthroughs in machine learning and deep learning. Fig. 2 illustrates the major milestones in this evolution, highlighting seminal advancements that shaped the trajectory of generative AI [16].

Table 1
Key aspects of artificial intelligence.

Resources	Description	Key aspect
[9]	Agent AI can also run autonomously through planning, learning, and environmental data to make decisions without necessarily requiring direct human intervention. As a result, they can perform very complex tasks successfully.	**autonomy**
[10]	These agents pursue and optimize performance toward certain objectives with the ultimate goal of achieving desirable outcomes. For instance, they can be used to find the best routes in transportation to minimize costs.	**Goal-oriented behavior**
[11]	An AI agent interacts with its surroundings, perceives changes, and adapts its strategies accordingly. This feature allows them to work effectively in dynamic and complex situations.	**Interaction with the environment**
[12]	Most artificial intelligence systems implement either machine learning or reinforcement learning to improve their performance over time. This functionality enables them to use their past experiences to achieve improved results.	**Ability to learn**
[13]	Agent AI promotes workflow optimization and business processes by combining language understanding, reasoning, planning, and decision-making. This includes optimizing resource allocation, improving communication and collaboration, and identifying automation opportunities.	**Workflow optimization**
[14]	An Artificial Intelligence Agent enables communication among agents for the creation of complex workflows. It can also be integrated with several other systems or tools, such as email, code execution, or search engines, to perform various tasks.	**Multiagent dialog and system**

2.1. Timeline of key technological breakthroughs

1. Early Rule-Based Systems (Pre-2000s)
   o AI systems primarily relied on hand-crafted rules and expert systems for problem-solving. These systems lacked adaptability and required extensive manual programming.
2. Integration of Machine Learning (2000s)
   o AI models began leveraging statistical learning techniques to improve decision-making. The introduction of large-scale datasets and early neural networks enhanced pattern recognition and data-driven insights.
   o **Key milestone:** Rise of Natural Language Processing (NLP) and basic machine learning algorithms.

3.Deep Learning Revolution (2010s)
   o The advent of deep learning significantly advanced AI capabilities. The introduction of demonstrated the power of convolutional neural networks (CNNs) in image recognition [17].
   o The development of the **Transformer architecture** revolutionized NLP, enabling context-aware language models and multimodal processing [18].
   o **Key milestone:** Transformer models paved the way for the rise of powerful AI systems capable of processing multimodal inputs.

4. Generative AI and Multimodality (Late 2010s–2020s)
   o AI models became capable of generating high-quality content across different modalities. The introduction of **GPT models** demonstrated the power of generative models in text generation.
   o **DALL·E** expanded AI capabilities to image-text alignment and multimodal reasoning.
   o **Key milestone:** The fusion of NLP, computer vision, and audio processing in large-scale AI systems.
5. Advanced Autonomy and Real-Time Interactions (2020s onwards)
   o AI agents are now capable of self-supervised learning, autonomous decision-making, and real-time multimodal interactions.

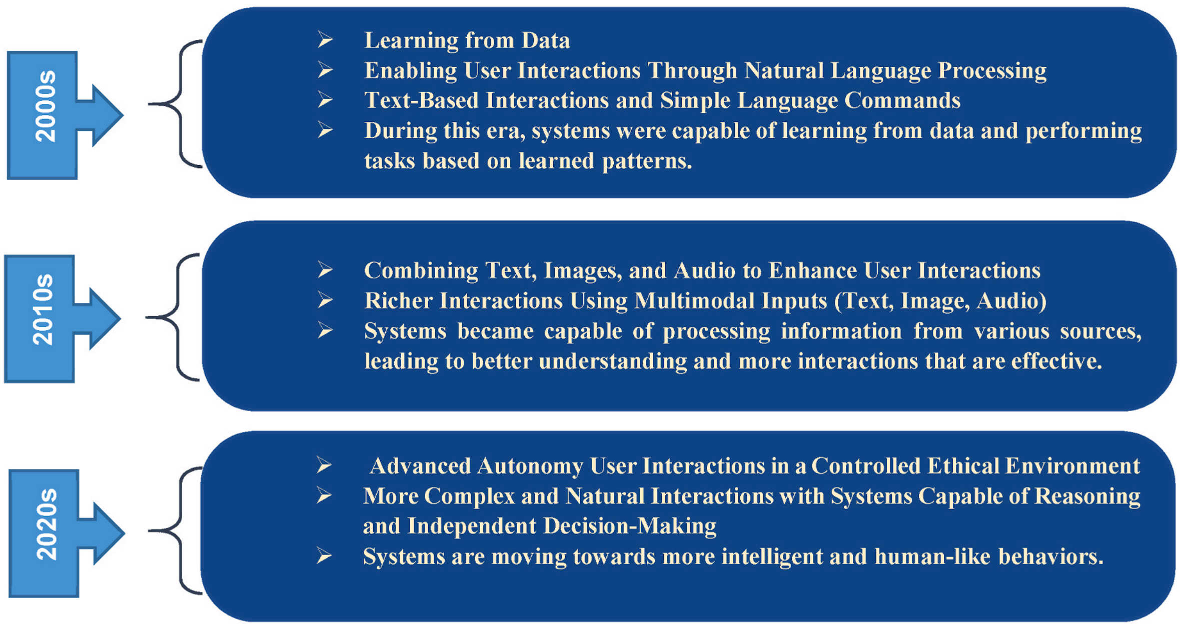

Fig. 2. Summarizes the major evolution stages, their key features, and user-system interaction.

o AI-driven systems, such as **ChatGPT-4**, integrate diverse modalities, allowing for more nuanced and intelligent responses.
o **Key milestone:** AI-powered autonomous systems, such as self-driving cars and real-time customer support bots, are transforming industries.

2.2. Machine learning and multimodal capabilities

2.2.1. Machine learning (ML) in multimodal agents

- **Data Learning:** Machine learning enabled agents to continuously learn from vast datasets, allowing them to refine decision-making and improve task performance dynamically.
- **Advancements in NLP:** Large-scale language models, such as **BERT**, enhanced AI's ability to understand and generate human language.

2.2.2. Multimodal processing and integration

- **Mixture of Text, Images, and Sound:** AI agents can now analyze and synthesize information from various sources, providing richer and more context-aware interactions.
- **Advanced User Interactions:** Multimodal agents facilitate dynamic exchanges, such as answering questions based on image analysis or understanding voice commands within complex contexts.

2.2.3. Advanced Autonomy and ethical considerations

- **Human-like Reasoning:** AI agents can set goals, make independent decisions, and optimize solutions autonomously.
- **Ethical and Responsible AI:** With increased capabilities, ethical considerations, such as data privacy, security, and bias mitigation, have become central to AI development.

2.3. Advanced Autonomy and Real-Time Interactions

Agents are able to act autonomously, set their goals, design pathways to achieve these goals, and make decisions independently, without the need for continuous interference from humans. This capability is achieved through multi-sourced or synthetic data. A multi-agent system may consist of one group of agents performing fast thinking and providing initial approaches, such as ChatGPT-4, and another group performing slow reasoning and providing revised solutions, such as ChatGPT-1. The combination of these two approaches empowers agents to carry out real-time processing of information and make optimal decisions, which is particularly important for applications like autonomous vehicles, real-time customer service, and mission-critical business processes [19].

Briefly, as illustrated in Table 2, AI agents have evolved from simple rule- and data-based systems to more complex and multi-faceted systems that can understand and interact with the real world intelligently. They have reached a point where they enable everything from simple data analytics and chatbots to self-driving cars and real-time customer support systems. Moreover, with advancements in artificial intelligence capabilities, it has become necessary to pay closer attention to ethical and responsible considerations.

3. Agent-Based Artificial Intelligence and its impact on the productivity, competitiveness, and innovation of organizations

The integration of **Agent-Based Artificial Intelligence (ABAI)** into organizational processes has shown.

Empirical studies indicate that organizations deploying ABAI experience substantial efficiency gains. For example, a McKinsey report found that AI-driven automation can improve productivity by up to 40 % in some industries by reducing manual workloads and optimizing workflows. In financial services, JPMorgan Chase's AI-driven COiN platform processes legal documents in seconds—tasks that previously took lawyers 360,000 h annually [20].

In manufacturing, predictive maintenance powered by ABAI has reduced equipment downtime by 20–50 %, leading to significant cost savings [21]. In customer service, AI-powered chatbots have decreased response times by 60 % while increasing customer satisfaction scores by 25 % [22].

Competitive Advantage and Innovation.

Organizations leveraging ABAI gain a competitive edge through data-driven insights and automation. AI agents in the retail sector optimize inventory management, reducing stockouts by 30 % while improving demand forecasting accuracy by 85 % [23]. In financial markets, AI-driven trading platforms have increased profitability margins by leveraging real-time data and predictive analytics.

Table 2
Evolution of the multifaceted agents of productive artificial intelligence.

stage	Decade	Details	Applications
Integrating Machine Learning (ML)	2000s	Learning from Data: Agents gained the ability to learn from large datasets, enabling them to make decisions based on trained data instead of relying on fixed rules	- Big Data analysis, recognizing patterns in structured and uneven data.
		NLP-based Interactions: Advances in natural language processing (NLP) have allowed agents to better understand human language, making interactions more natural and intuitive.	- Chatbots, automatic translation, sentiment analysis in the text.
Introducing multimodality	2010s	Combination of Text, Images, and Sound: Agents gained the ability to process and integrate information from different sources, such as text, images, and sound.	- Image analysis, object identification, audio to text translation.
		Enhanced User Interactions: Agents were able to interact more dynamically with users, for example, providing visual responses or understanding a combination of text and voice input.	- Customer support systems, multimodal chat bots.
Advanced autonomy and real-time interactions	2020s onwards	Human-like Reasoning and Advanced Autonomy: Agents gained the ability to make independent decisions, define goals, and implement them without the need for constant human intervention.	- Self-driving vehicles, real-time customer support systems.
		User Interactions in an Ethical and Responsible Controlled Environment: With advancements in capabilities, the focus on ensuring the ethical and responsible performance of agents has increased.	- Use of artificial intelligence in health, transportation, and mission-sensitive business processes.

Beyond operational efficiencies, ABAI fosters innovation by enabling organizations to experiment with new business models. For instance, AI-powered design tools in the automotive industry have accelerated the prototyping process, reducing product development time by 50 % [24].

3.1. Challenges and considerations

Despite these advantages, ABAI implementation presents several hurdles.

- **High Computational Costs**: The deployment of AI agents requires significant processing power. Training deep learning models for decision-making can cost companies millions in cloud computing and infrastructure.
- **Decision-Making Transparency**: Many AI systems function as black boxes, making it difficult for organizations to understand how decisions are made, which can lead to regulatory and ethical concerns.
- **Data Bias and Fairness**: AI systems learn from historical data, which may contain biases. For example, a study found that AI-driven hiring tools exhibited biases against certain demographic groups, necessitating ongoing audits and bias mitigation strategies.

3.2. Comparison of agentic AI, generative AI, and autonomous AI

The distinctions between Agentic AI, Generative AI, and Autonomous AI are noteworthy in the sense of understanding their capabilities, uses, and limitations. Table 3 is a structured comparison.

4. Artificial intelligence systems with hierarchical architecture

Fig. 3 depicts an artificial intelligence system with a hierarchical architecture, which organizes interactions and processes within it to be built and executed at multiple levels in the form of a top-to-bottom hierarchy. The architecture is such that at each level, a responsibility, task, or decision may be considered in relation to the higher or lower level. The mission of each agent in an artificial intelligence system with a hierarchical architecture is presented below [25].

In other words, Table 4 shows how an agent-based AI system distributes several tasks among multiple agents by using the concept of hierarchy to enhance the performance of the overall system. The main agent will control and coordinate with other agents, while other agents perform specific tasks at each level. This also creates room for the development and addition of new agents to perform specialized tasks.

Agent-based AI systems have the potential to help organizations manage everyday tasks more effectively and provide a new form of "AI-as-a-Service" (AIaaS). This involves transforming manual work into automated services based on artificial intelligence. Instead of buying a traditional software license or subscribing to cloud-based Software-as-a-Service (SaaS), businesses will pay for the specific results delivered by the AI agents.

For instance, an organization might deploy AI customer support agents, like Sierra, on the company website to help resolve problems and pay only for the number of issues resolved, rather than investing heavily in a human support workforce. This model offers a range of services—for example, legal support through AI-driven lawyers, AI-driven penetration testers who continuously test for cybersecurity gaps, and CRM management in auto-mode—all at a fraction of the cost. It enhances productivity by reducing operating costs by up to 30 % while increasing response efficiency by 40–50 % [26,27].

4.1. Cost-to-benefit analysis

The AIaaS model enables the automation of tasks ranging from routine to high-skill, which previously required an enormous amount of time, professional effort, and expensive software licenses or cloud solutions.

- **Short-Term Costs:** Initial implementation of AI-driven solutions can range from $50,000 to $500,000, depending on the complexity and industry-specific requirements.
- **Long-Term ROI:** Companies that integrate AIaaS solutions have reported a 20–35 % reduction in operational costs within the first two years and an average ROI of 3x to 5x over five years [28].
- **Industry-Specific Impact:**

Table 3
Comparison of agentic AI, generative AI, and autonomous AI.

FEATURE	AGENTIC AI	GENERATIVE AI	AUTONOMOUS AI
Definition	AI that interacts with its environment and performs actions based on given inputs or objectives.	AI that generates new content, such as text, images, or music, based on learned patterns.	AI that operates independently, making decisions and executing actions without direct human intervention.
Primary Function	Decision-making and task execution in response to environmental inputs.	Content creation through pattern recognition and synthesis.	Fully autonomous operation with real-time adaptation and decision-making.
Degree of Autonomy	Semi-autonomous; relies on predefined rules or learned behaviors.	Typically non-autonomous; generates outputs based on input queries.	Fully autonomous, capable of self-directed decision-making.
Examples	Virtual assistants (e.g., Siri, Alexa), recommendation systems, automated trading bots.	Text generators (e.g., ChatGPT), image generators (e.g., DALL·E), music composition AIs.	Self-driving cars, autonomous drones, robotic surgery systems.
Core Technologies	Reinforcement learning, expert systems, rule-based AI.	Deep learning, neural networks (e.g., transformers, GANs).	Advanced machine learning, real-time sensory processing, reinforcement learning.
Interaction with Humans	Moderate; designed for guided interactions and responses.	High; relies on user input to generate content.	Low to none; operates independently with minimal human oversight.
Decision-Making Process	Responds to inputs based on programmed logic or learned strategies.	Produces new outputs based on trained models but lacks reasoning capabilities.	Evaluates multiple variables in dynamic environments to make autonomous decisions.
Learning Mechanism	Learns from structured inputs and feedback loops.	Trained on vast datasets but does not learn from real-time interactions.	Continuously learns from real-world interactions and adapts dynamically.
Adaptability	Can adjust responses based on predefined learning parameters but lacks real-time evolution.	Limited adaptability; improves with retraining but does not self-improve dynamically.	Highly adaptive; modifies behavior based on new information and changing environments.
Memory and Retention	Short-term memory for task execution, may retain user preferences.	No true memory; generates outputs based on training data but does not retain user interactions.	Long-term memory; stores and recalls information to improve future decision-making.
Real-Time Processing	Can process real-time inputs but usually follows predefined rules.	Generates content based on pre-trained data, not real-time information.	Processes real-time data and makes decisions instantaneously.
Error Handling	Follows programmed logic for error correction but may struggle in novel situations.	Outputs may contain biases or inconsistencies but lack self-correction abilities.	Detects and corrects errors autonomously, improving performance over time.
Complexity of Tasks	Moderate complexity; performs specific tasks but requires human guidance.	Primarily creative and data-driven tasks; lacks reasoning for complex problem-solving.	Handles complex, multi-variable tasks with independent problem-solving capabilities.
Ethical and Safety Concerns	Risks include biased decision-making and lack of deep understanding.	Concerns include misinformation, copyright issues, and ethical content generation.	High safety risks in critical applications (e.g., self-driving cars, autonomous weapons).
Use Cases	Customer support, cybersecurity monitoring, financial advisory bots.	Automated writing, AI-driven design, deepfake creation, music and video generation.	Military applications, healthcare automation, smart city management, industrial robotics.

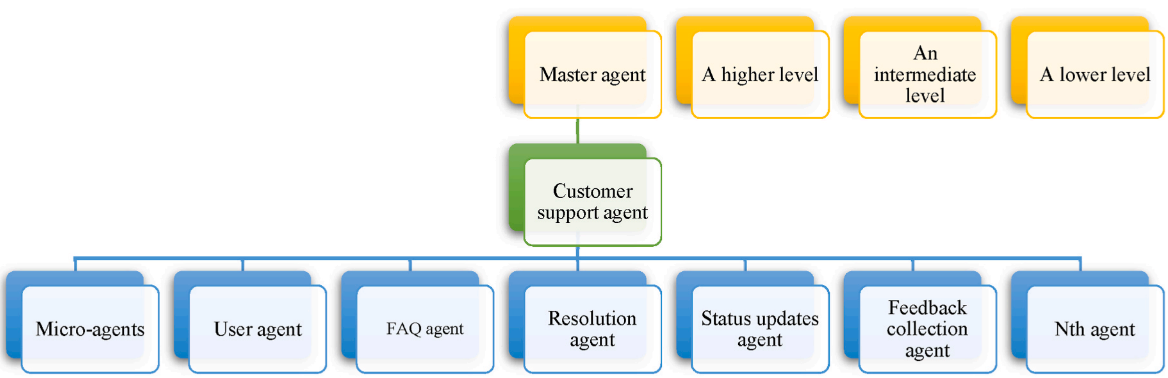

Fig. 3. Different levels of agents in agent-based AI systems.

o **Retail**: AI-powered inventory management can reduce overstocking costs by 25 % and increase sales forecast accuracy by 85 %.
o **Finance**: AI-driven fraud detection systems have reduced fraudulent transactions by 40 %, saving companies millions annually.
o **Healthcare**: AI-based diagnostic tools cut diagnostic errors by 30 % and reduce patient processing time by 50 %, improving efficiency and patient outcomes [29].

Advanced AI, now capable of complex reasoning, can execute everything from software engineering to managing customer service centers, allowing companies to scale operations without a corresponding increase in costs. This transition makes such services accessible to organizations of all sizes, enabling them to focus on strategic priorities while operational workloads are handled by AI systems. Companies that fail to integrate AI risk falling behind, as competitors leveraging AI-driven automation can deliver services faster, reduce costs, and enhance decision-making.

Adopting these AI-based services positions businesses to remain competitive in an ever-evolving market, ensuring they stay relevant and resilient.

5. Transition from Mobile Models (Copilot) to autonomous models (Autopilot)

The evolution of artificial intelligence (AI) in organizational settings, as shown in Fig. 4, represents a strategic, outcome-driven transformation that guides businesses from their current state to a more advanced, autonomous future. This progression unfolds through two key stages: the "Copilot model" and the "Autopilot model," each offering unique benefits, challenges, and operational implications.

Table 4
Artificial intelligence system operating with hierarchical architecture.

1. **Master agent:** At the top of the pyramid, the master agent oversees and manages the workings of the whole system. In this model, that agent is known as the "Customer Support Agent." It is at the apex level of the pyramid as a supervisor over all other processes, giving instructions for each of the sub-agents' next actions.
2. **Orchestrator agent:** Below the master agent, an orchestrator agent divides tasks among different sub-agents. For example, another customer support agent at this level is responsible for coordinating with sub-agents and managing processes.
3. **Micro-agents**: The lowest level comprises sub-agents or micro-agents, each of which plays a specific role in the customer support process. Some of these include:

- **User Experience Agent**: Enhances the user experience and communicates positively with the customer.
- **FAQ Agent**: Helps customers find answers to frequently asked questions.
  - **Issue Resolution Agent**: Solves problems and issues for customers and provides solutions.
  - **Status Update Agent**: Updates information related to the status of a request or customer service.
- **Feedback Collection Agent**: Collects customer feedback to improve processes and services.

5. Business Imperatives of Artificial Intelligence

LEVEL	AGENT NAME	DUTY
higher level	Master agent	General control and system management
Intermediate level	Customer support agent	Customer support
Intermediate level	Customer support agent	Customer support
Lower level	Micro-agents	Implementation of specific and small tasks
Lower level	User agent	User interaction
Lower level	Agent FAQ	Answering frequently asked questions
Lower level	Resolution agent	Solving issues and problems
Lower level	Status update agent	Send status updates
Lower level	Feedback collection agent	Collect feedback
Lower level	Nth agent	Agent Nam for special tasks

Definitions:

- **Copilot Model**: In this model, AI systems function as assistants to human operators, providing support, recommendations, and error reduction while operating within a "human-in-the-loop" framework. The Copilot model emphasizes collaboration, where AI enhances human decision-making and productivity without fully replacing human oversight.
- **Autopilot Model**: In contrast, the Autopilot model represents fully autonomous AI systems capable of operating independently without human intervention. These systems are designed to execute tasks, make decisions, and optimize outcomes with minimal or no human supervision, achieving higher efficiency and scalability.

5.1. Strategic progression and organizational change

Fig. 4 visually illustrates this transition as a journey from the Copilot to the Autopilot model, emphasizing how Service-as-Software drives strategic, outcome-oriented change. Organizations begin with AI as a supportive tool, gradually establishing trust and reducing human errors while retaining human oversight. As trust and capabilities grow, businesses can progress toward fully autonomous systems, leading to lower operational costs and improved efficiency. However, not all AI solutions include built-in backups like Sierra's referral to human agents, making the "human-in-the-loop" strategy a common and effective approach for initial AI integration [29]. This gradual progression ensures organizations can adapt to AI advancements while mitigating risks, ultimately reaching a stage where autonomous models deliver significant performance improvements.

5.2. The Copilot model: AI as a human assistant

Phase, AI supports and enhances human work rather than replacing it, functioning within a "human-in-the-loop" framework. For instance, an AI system like Sierra, mentioned in the customer service context, acts as a safety net by escalating complex issues to human agents when necessary, thereby improving the customer experience. This collaborative approach has several key advantages.

1. Trust in Artificial Intelligence Grows: By collaborating with humans, employees gradually become more comfortable with AI, fostering confidence in its capabilities.
2. Reduction of Human Errors: AI can identify mistakes or suggest improvements, decreasing the likelihood of human oversight.
3. Increase in Employee Productivity: With AI managing routine tasks, employees can concentrate on higher-value activities, enhancing overall efficiency.
4. Need for Human Supervision: While AI provides assistance, human oversight remains crucial to ensure accuracy and manage complex situations.
5. Likelihood of Errors in Complex Scenarios: Despite its advantages, the Copilot model may still struggle with highly complex or unpredictable situations, requiring human intervention to mitigate possible mistakes.

This stage is critical for organizations aiming to integrate AI gradually, allowing them to build trust and refine processes before moving to full automation.

5.3. The Autopilot model: fully autonomous AI

The Autopilot model signifies the next evolutionary step, where AI operates automatically and independently, removing the need for human oversight. This stage is marked by increased autonomy and efficiency, enabling organizations to achieve better performance and cost savings. The primary benefits of the Autopilot model include.

1. Efficiency Increases: Autonomous AI systems can execute tasks more quickly and consistently, streamlining operations.
2. Performance Enhancements: With advanced algorithms and ongoing learning, AI can optimize outcomes and produce exceptional results.
3. Reduced Need for Human Supervision: By functioning independently, these systems lessen the dependence on human intervention, allowing resources to be allocated to other priorities.
4. Operational Cost Reductions: Fewer human resources are required for oversight and manual tasks, resulting in significant cost savings.
5. Likelihood of Errors in Complex Scenarios: While still a concern, autonomous systems are designed to navigate complex scenarios with fewer errors, although continuous monitoring and updates may be necessary to maintain reliability.

5.3.1. Transition from Copilot to Autopilot

The transition from Copilot to Autopilot models involves a gradual shift from human-AI collaboration to full autonomy. This progression is driven by advancements in AI capabilities, increased trust in AI systems, and the need for greater operational efficiency. Organizations typically begin with Copilot systems to build confidence, refine processes, and address limitations in complex scenarios. As AI systems demonstrate reliability and performance, they evolve into Autopilot models, where human oversight is minimized, and AI takes on more responsibility.

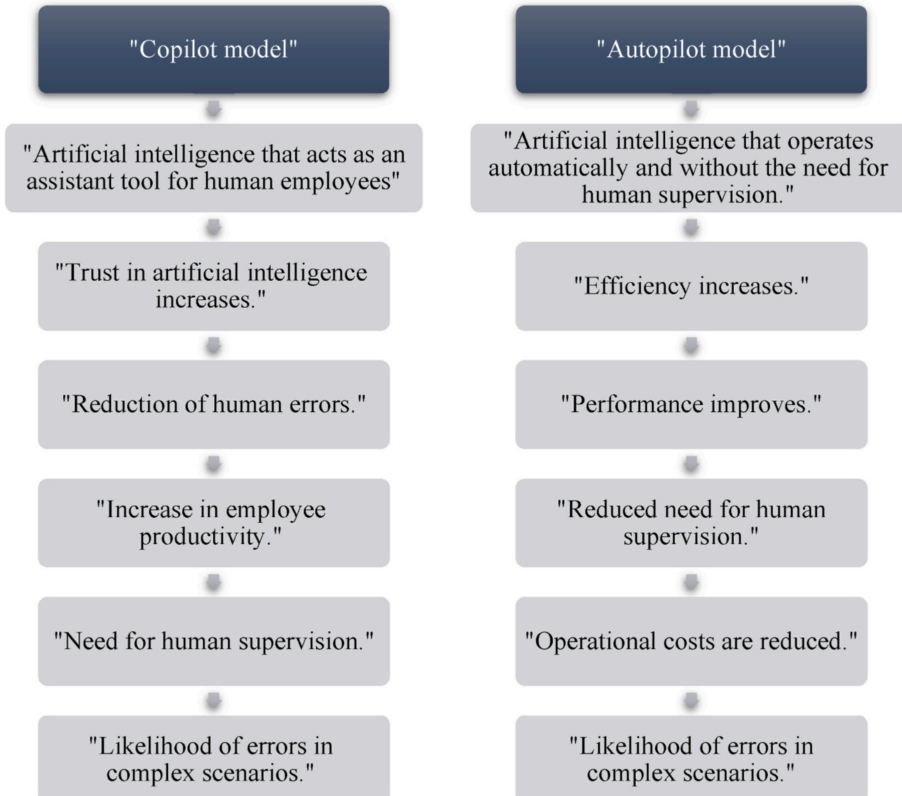

Fig. 4. Transition from mobile models (Copilot) to autonomous models (Autopilot).

Real-World Examples of Transition.

- **Customer Service:** Early AI chatbots (Copilot) assist human agents in answering trivial questions and referring complex issues. With time, machine learning advancements and natural language processing enable fully independent chatbots (Autopilot) to take up the majority of customer issues independently [30].
- **Autonomous Vehicles**: Early autonomous vehicles (Copilot) require human drivers to step in and take over in challenging conditions. With technology, fully autonomous vehicles (Autopilot) operate on their own, navigating complex routes without human intervention [31,32].
- **Healthcare Diagnostics**: AI systems initially support doctors by analyzing medical images and suggesting diagnoses (Copilot). With higher accuracy and validity, the systems move on to diagnose independently and suggest treatments (Autopilot) [33,34].

Impacts of the Transition.

- **Positive Impacts**: The shift to Autopilot systems leads to increased efficiency, reduced operational costs, and enhanced performance. Organizations can scale operations more effectively, and employees can focus on higher-value tasks.
- **Challenges**: The transition poses challenges such as ensuring reliability in complex scenarios, addressing ethical concerns, and managing workforce displacement. Additionally, maintaining system security and adapting to regulatory requirements are critical hurdles.

5.4. Future directions

After acquiring Autopilot systems, the next hurdle is to develop Adaptive AI self-improving systems that can learn from changing circumstances and make contextually informed decisions in real-time.

5.4.1. Explainable Agentic AI

One key process in such evolution is bringing Explainable AI (XAI) into agentic systems, where autonomous agents make high-stakes or autonomous choices. Explainable Agentic AI focuses on enhancing transparency, accountability, and user trust by enabling humans to comprehend the decision-making process behind an agent's action. This is especially crucial for safety-critical settings such as healthcare, finance, and autonomous driving. XAI techniques may assist in bringing agentic behavior into line with human norms and morality [35].

5.4.2. People-to-AI collaboration

An essential direction for future work is People-to-AI collaboration, with an emphasis on establishing AI systems that work together with humans in collaborative partnership rather than as mere tools. This, in agentic systems, means capabilities such as dynamic goal-sharing, negotiating in real time, shared decision-making, and adaptive task allocation. Such collaboration is poised to take productivity and innovation to new levels in application fields like education, scientific discovery, and the creative industries [36,37].

5.4.3. Federated Agentic AI

With greater emphasis on decentralization and data privacy, Federated Agentic AI is an interesting research area. These are systems where intelligent agents learn from decentralized data repositories without exchanging raw data, hence preserving user privacy. These systems are required in sensitive domains like healthcare and finance, where laws on privacy and security prohibit data centralization. Federated learning enables these agents to collaborate without moving data to a different location [38,37].

Beyond these specific fields, the intersection of AI with other emerging technologies such as quantum computing and next-generation robotics could unlock hitherto unimaginable capabilities. This development would potentially pave the way for Cognitive Autopilot systems that mimic human reasoning, situational awareness, and creative problem-solving. This transition to Autopilot and beyond is a mature stage of AI integration that allows organizations to reach new heights of productivity and scalability, but requires robust frameworks to cope with complexity, safety, and ethical issues.

6. Outsourcing work through artificial intelligence services

Outsourcing with the help of artificial intelligence involves AI technologies performing tasks on behalf of an organization as specified. This approach offers organizations with costly operations an opportunity to outsource specific tasks requiring assured results to AI services. As shown in Table 5, early adopters of AI gain first-mover advantages by setting industry standards, innovating business processes, and building stronger customer relationships. Late movers, however, face challenges in catching up, potentially losing their competitive edge and market shareware, and incurring higher opportunity costs due to delayed AI adoption. For example, the use of bots like Sierra for customer support to handle product-related queries is quite popular today. In this model, organizations pay only for the number of successfully resolved issues, rather than the fixed fees typically associated with software or cloud services [39].

Benefits:

1) Lower cost: Organizations do not have to pay fixed fees but only for the delivered results, thereby reducing operating costs.
2) Higher efficiency: Artificial intelligence can perform tasks automatically and with greater accuracy.
3) Scalability: Organizations can deploy varied scales of AI services without needing large investments.
4) Focus on the core goal: Organizations can devote more attention to their core activities and leave minor tasks to artificial intelligence.

Disadvantages:

1) Dependence on technology: Organizations may start relying heavily on technologies, which can lead to operational issues in case of AI service disruptions.
2) Limitation in personalization: Many tasks require extensive customization, which AI cannot achieve solely.
3) Privacy and security issues: Outsourcing data to external services raises concerns about data privacy and security.
4) Hidden costs: Sometimes, hidden costs related to training and deploying AI may increase overall expenses.

Table 5
Comparison of early and late adopters of artificial intelligence technologies.

Feature	(Early Adopters)	(Late Movers)
Market position	Determining industrial standards and gaining primary market advantage	Trying to compensate for the lag and losing the opportunity to create a competitive advantage
Innovation	Using artificial intelligence to innovate business processes, effectively deploying **AI** solutions, and creating differentiation	Slowness in business process innovation and **underutilization** of **AI** solutions to create differentiation
Customer relations	Building deeper relationships with customers through personalized and innovative experiences	Trying to catch up to provide personalized services similar to early adopters
operational efficiency	Simplifying operations and reducing operational costs from the start	Higher lost opportunity cost due to late entry and acceptance
Learning curve	Taking advantage of the initial learning curve and shaping industry standards	Missing early learning opportunities and influencing the industry
market share	Increase market share and profitability through early adoption	Trying to achieve similar market share
barriers to entry	**Increasing** market share and profitability through early adoption	Facing higher barriers to entry due to competitors
Entrance fee	Paying a relatively high entrance fee and repeated tests due to new **AI** solutions	Paying a relatively lower entrance fee and fewer tests

The table provides a comparative analysis of early adopters and late movers in adopting artificial intelligence (AI) technologies. This section expands on this by exploring real-world use cases of AI outsourcing across various industries, supported by market data and statistics, and discusses potential risks and challenges along with mitigation strategies.

6.1. Real-world use cases of AI outsourcing

In the healthcare industry, AI outsourcing is widely utilized for medical imaging analysis and diagnostics. Companies like IBM Watson Health outsource AI algorithms to analyze X-rays, MRIs, and CT scans, assisting radiologists in detecting diseases such as cancer with greater accuracy. Industry reports indicate that the global AI healthcare market was valued at approximately $196.63 billion in 2023 and is projected to reach $1811.75 billion by 2030, growing at a CAGR of 36.6 %, with outsourcing reducing diagnostic times by up to 30 % and improving patient outcomes. In retail and e-commerce, giants like Amazon and Walmart leverage AI outsourcing for demand forecasting, inventory management, and personalized customer recommendations, where algorithms analyze consumer behavior to optimize stock levels and tailor marketing campaigns. This market was valued at $241.8 billion in 2023 and is expected to grow to $740 billion by 2030 with a CAGR of 17.4 % (adjusted for retail-specific growth trends), with outsourcing improving supply chain efficiency by 20–30 %. In the financial sector, banks such as JPMorgan Chase outsource AI for fraud detection and risk assessment, using models to analyze transaction patterns and identify anomalies in real-time, reducing fraud losses by about 25 % for early adopters. Additionally, companies like General Electric in manufacturing use AI outsourcing for predictive maintenance, employing machine learning to predict equipment failures and minimize downtime; this market, valued at $214.6 billion in 2024, is projected to reach $1339.1 billion by 2030 with a CAGR of 35.7 %, enhancing equipment uptime by 20 % [40].

6.2. Market data and statistics

The global AI outsourcing market was estimated at $214.6 billion in 2024 and is forecasted to grow to $1339.1 billion by 2030, driven by the need for cost efficiency and access to specialized expertise. Early adopters have experienced a 15–20 % increase in profit margins due to operational efficiencies, while late movers face 10–15 % higher initial costs to compete with established players, reflecting a competitive landscape where early investment yields significant advantages [41].

6.3. Risks and challenges of AI outsourcing

One major challenge is concerns over data security and privacy, as outsourcing sensitive data to third-party providers can lead to breaches or non-compliance with regulations like GDPR or HIPAA. This risk can be mitigated by implementing robust encryption, conducting regular security audits, and signing strict data protection agreements with vendors. Quality control is another issue, as variability in AI model performance from outsourced providers can impact reliability and customer trust, which can be managed by establishing clear performance benchmarks, conducting periodic testing, and maintaining an in-house team to oversee outputs. Dependency on vendor's poses risks as well, since over-reliance on external providers can create vulnerabilities if a vendor fails or discontinues services; this can be addressed by diversifying vendor partnerships and developing in-house AI capabilities as a backup. Cultural and communication gaps, stemming from differences in time zones, languages, and work cultures, can hinder collaboration with outsourced teams, but this can be overcome by using project management tools, hiring cultural liaisons, and scheduling overlapping work hours for critical tasks. Finally, unexpected costs from repeated testing or customization of AI solutions can erode financial benefits, and this challenge can be controlled by negotiating fixed-price contracts with clear deliverables and including clauses for cost escalation reviews [42].

7. Commercial and Open-Source Solutions

Commercial and open-source AI solutions, offer a variety of tools tailored to diverse audiences, including startups, established companies, large enterprises, developers, and AI enthusiasts. These solutions are designed to meet specific needs and objectives, each with unique features, capabilities, and use cases. Below, we provide a clear distinction between commercial and open-source AI solutions, discuss their unique features, and include examples of popular platforms such as IBM Watson and Amazon SageMaker. We also explore future implications and trends, including AI-as-a-Service (AIaaS) and regulatory frameworks to mitigate AI misuse.

Commercial AI solutions are proprietary, developed by companies that charge licensing or subscription fees for access. They are designed to be user-friendly, often pre-configured for specific industries, and come with dedicated support, maintenance, and compliance features, making them ideal for enterprises with strict regulatory needs. However, they involve high costs, recurring fees, and potential vendor lock-in, which can limit flexibility and transparency since the source code is not publicly accessible. In contrast, open-source AI solutions are freely available, with publicly accessible source code, allowing for extensive customization and community-driven development. They are cost-effective, particularly for startups and researchers, but often require significant technical expertise, infrastructure investment, and in-house maintenance, which can lead to challenges in scalability, security, and quality assurance for enterprise-grade applications [43].

7.1. Unique features, capabilities, and real-world use cases

Commercial AI Solutions.

Commercial platforms prioritize ease of use, scalability, and enterprise-grade features. They often include pre-built models, seamless integrations, and robust support systems, catering to businesses seeking rapid deployment and compliance with industry standards.

- **LangGraph (Commercial)**: Designed for startups and established businesses, LangGraph enhances workflows in customer support and professional services with high customization and advanced capabilities like statefulness (retaining memory of prior interactions), streaming support, and monitoring loops. Its seamless integration with existing enterprise systems makes it suitable for companies needing precision in workflow control. For example, a mid-sized tech firm might use LangGraph to streamline its customer support ticketing system, ensuring context-aware responses across multiple interactions.
- **CrewAI (Commercial)**: Tailored for Fortune 500 companies and large enterprises, CrewAI offers no-code tools and templates for quick deployment, supporting both self-hosted and cloud options. It excels in managing complex, multi-faceted tasks with comprehensive support and maintenance services. A real-world example includes a global retailer using CrewAI to automate supply chain operations, optimizing logistics and inventory management across multiple regions.
- **IBM Watson (Commercial)**: IBM Watson provides a suite of AI services for industries like healthcare, finance, and retail, featuring natural language processing (NLP), predictive analytics, and image recognition. Its enterprise-ready design includes pre-trained models and tools for custom model training, with a focus on compliance and scalability. In healthcare, Merative (formerly IBM Watson Health) uses Watson for medical image analysis, enhancing diagnostics and personalizing medicine, such as analyzing MRIs to detect early signs of cancer with higher accuracy.
- **Amazon SageMaker (Commercial)**: Amazon SageMaker streamlines the creation, training, and deployment of machine learning models, supporting data scientists and business analysts with features like geospatial ML and standardized MLOps practices. It enables over a trillion predictions per month, significantly reducing training times and costs. For instance, a financial institution might use SageMaker to build fraud detection models, analyzing transaction patterns in real-time to flag suspicious activities, as seen in its ability to handle large-scale projects efficiently.

7.2. Open-source AI solutions

Open-source platforms emphasize transparency, flexibility, and community collaboration, allowing users to modify and fine-tune models to suit specific needs. They are often more cost-effective but require technical expertise for implementation and maintenance.

- **AutoGen (Open-Source)**: Designed for AI developers and researchers, AutoGen facilitates collaboration between multiple AI agents, simplifying the coordination, automation, and optimization of complex LLM workflows. It supports human-assisted workflows and fosters innovation through its open-source community. For example, academic researchers might use AutoGen to develop a multi-agent system for simulating economic models, leveraging its collaborative framework to test various scenarios.
- **AutoGPT (Open-Source)**: Aimed at AI enthusiasts and developers, AutoGPT leverages the GPT-4 architecture to autonomously perform tasks by breaking down large goals into manageable sub-tasks, with internet access and code execution capabilities. It's widely used in content creation and customer service. A practical use case involves a small business employing AutoGPT to automate social media content generation, creating tailored posts based on trending topics.
- **TensorFlow (Open-Source)**: TensorFlow is a popular open-source library for building and deploying machine learning models, known for its comprehensive computer vision capabilities, scalability, and large community support. It's used across industries, from startups to enterprises. For instance, a startup might use TensorFlow to develop an image recognition app for inventory management, automating the identification of products in a warehouse.
- **Llama (Open-Source)**: Meta's Llama models, such as Llama 3.1, are open-source LLMs designed for flexibility and cost efficiency, particularly in enterprise settings. They are used by companies like AT&T for customer service automation, DoorDash for answering software engineering queries, and Goldman Sachs for regulated financial applications, showcasing their adaptability across sectors [44].

7.3. Future implications of commercial and open-source AI solutions

The future of AI solutions is shaped by emerging trends like AI-as-a-service (AIaaS) and evolving regulatory frameworks to mitigate misuse. AIaaS is gaining traction, with platforms like Amazon SageMaker and IBM Watson offering cloud-based AI services that reduce the need for in-house infrastructure, making advanced AI accessible to smaller businesses. This trend is expected to accelerate in 2025, driven by a more flexible regulatory environment in regions like the U.S., potentially favoring innovation over strict oversight, though industries like healthcare will continue to prioritize responsible AI use due to sensitive data concerns. Open-source AI is also poised for growth, with experts predicting that smaller, more efficient models will dominate, enabling edge computing and reducing reliance on external systems. Collaborative efforts, as seen in communities like Hugging Face, will drive innovation, particularly in ethical AI practices such as bias detection and transparency, spurred by regulations like the EU AI Act passed in 2024.

However, regulatory frameworks will play a critical role in addressing AI misuse. The EU AI Act emphasizes transparency, fairness, and accountability, pushing both commercial and open-source developers to enhance ethical auditing tools. In the U.S., a shift toward self-governance may accelerate innovation but could also increase risks of misuse, such as the spread of misinformation through generative models like Stable Diffusion if not properly safeguarded. Commercial solutions may benefit from stricter access controls and compliance features, while open-source models will need robust governance to prevent malicious use, balancing openness with security. Ultimately, a hybrid approach—combining the strengths of commercial and open-source AI—may

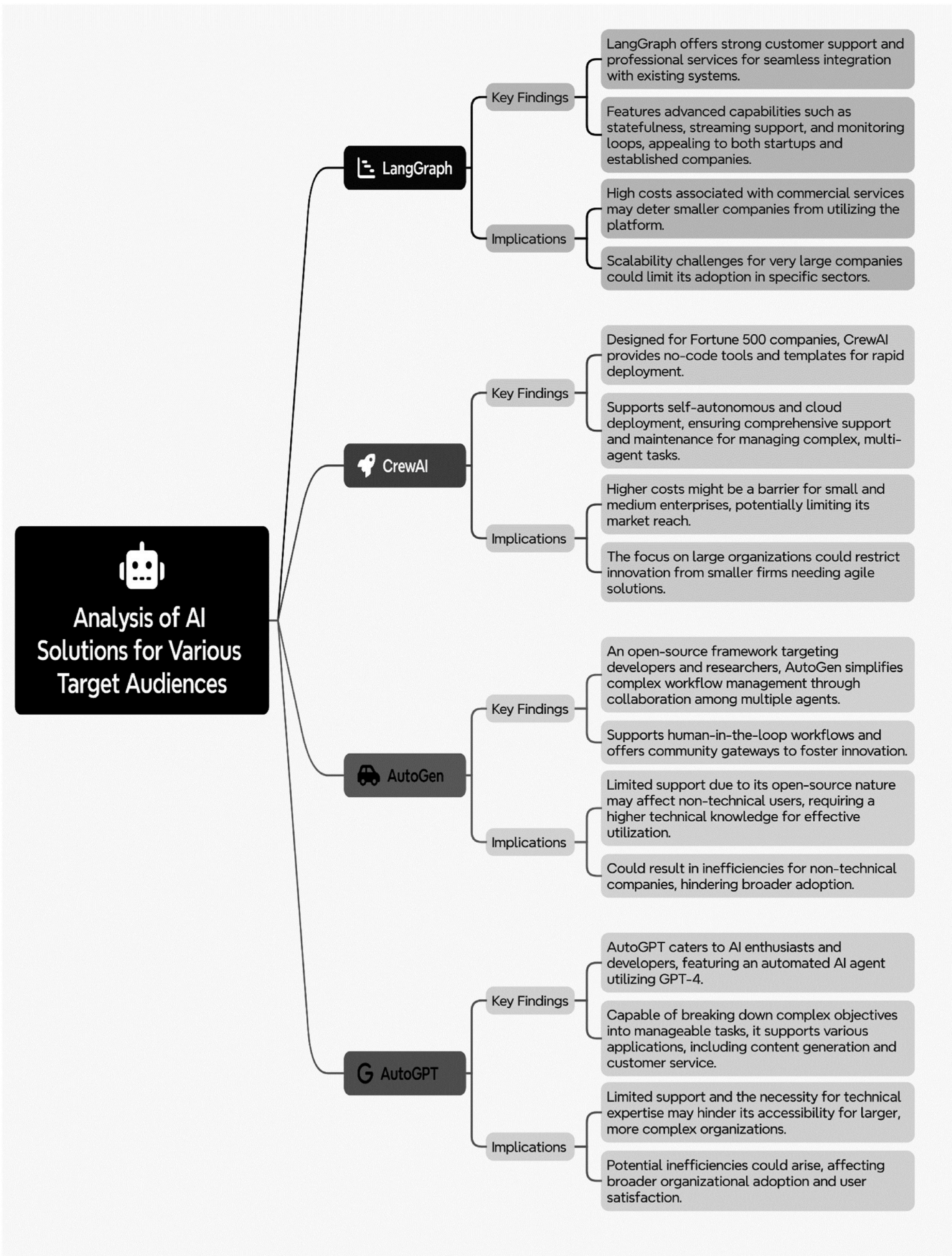

Fig. 5. Commercial and open-source solutions.

emerge as the most sustainable path, allowing businesses to leverage community-driven innovation while ensuring enterprise-grade reliability and compliance [45].

Fig. 5 some artificial intelligence solutions, both commercial and open-source, are designed for various audiences, from startups and large businesses to developers and AI enthusiasts. The specifications and uses mentioned above are intended to ensure efficiency and ease in the tasks involved in different AI projects. The commercial and free solutions discussed here are compared, highlighting their relative advantages and disadvantages.

Fig. 5 offers a systematic evaluation of various AI tools, assessing their compatibility with different user groups. It organizes four AI platforms LangGraph, CrewAI, AutoGen, and AutoGPT outlining their primary insights and significance. Below is a detailed and restructured breakdown of the information.

7.4. Comprehensive evaluation of AI platforms for diverse user bases

This segment delivers an extensive review of multiple AI tools, exploring their features, intended users, and possible drawbacks. The platforms under consideration are LangGraph, CrewAI, AutoGen, and AutoGPT.

1. LangGraph

LangGraph caters to organizations seeking robust customer assistance and effortless integration of AI into current systems. It boasts cutting-edge features like statefulness, real-time streaming, and monitoring mechanisms. These attributes make it attractive to both emerging startups and established corporations. LangGraph ensures thorough customer support and expert services to facilitate seamless adoption. It also includes sophisticated tools such as live tracking and state retention, enabling companies to sustain effective AI-powered processes. Its design accommodates the needs of both small ventures and large enterprises, offering a versatile option for diverse business requirements.

2. CrewAI

CrewAI is crafted specifically for Fortune 500 firms, providing no-code options and pre-built templates for swift AI implementation. It supports autonomous, cloud-hosted AI systems, delivering reliable management of multi-agent setups. With CrewAI, enterprises can deploy AI-enhanced workflows without deep programming knowledge, simplifying the handling of intricate tasks for major organizations. As a cloud-supported platform, it guarantees ongoing maintenance and scalability, ensuring consistent performance. Its emphasis on enterprise-grade automation positions it as a top pick for companies managing large-scale operations.

3. AutoGen

AutoGen serves as an open-source platform tailored for developers and academic researchers, streamlining AI workflow coordination via multi-agent teamwork. It prioritizes human-in-the-loop processes, encouraging creativity and advancements within the AI field. Its open-source nature allows users to adapt and enhance its capabilities to suit specific project demands. AutoGen boosts task automation by enabling collaboration among various AI agents, improving operational efficiency. Additionally, its human-supervised approach ensures that AI outputs can be monitored and refined, making it an essential resource for AI experimentation and innovation.

4. AutoGPT

AutoGPT targets AI hobbyists and programmers, harnessing GPT-4 to automate workflows and divide complex goals into simpler steps. This adaptability suits applications like content creation and customer service optimization. Operating as a fully independent AI agent, AutoGPT can tackle intricate tasks without constant human oversight. It supports diverse purposes, such as producing high-quality content and enhancing customer support automation. By segmenting tasks into clear, manageable parts, AutoGPT boosts productivity and minimizes manual workload, establishing itself as a valuable asset for both developers and businesses [46].

8. Strategy formulation for GenAI

The formulation of a Generative AI (GenAI) strategy involves a structured, holistic approach to effectively integrate and optimize generative AI technologies within businesses. This strategy outlines a clear path for deploying AI capabilities, addressing business needs, and ensuring long-term success. The following sections detail the key components, processes, and considerations for developing a robust GenAI strategy.

8.1. Vision and objectives

The foundation of a GenAI strategy begins with a compelling vision and specific, measurable goals to guide its implementation. This vision ensures alignment with organizational priorities while setting a clear direction for AI adoption.

- **Vision:** Define how GenAI can transform the business by enhancing customer experiences, improving operational efficiency, and driving innovation in products and services.
- **Objectives:** Establish SMART (Specific, Measurable, Achievable, Relevant, Time-bound) goals, such as reducing response times by 30 % within six months or increasing product innovation by 20 % annually through AI-driven insights.

8.2. Assessing needs and prioritizing use cases

A thorough understanding of business needs is critical to prioritize GenAI applications effectively. This step ensures resources are allocated efficiently and aligns AI efforts with strategic goals.

- **Business Needs Analysis:** Use methods like interviews, surveys, and business analytics to identify specific challenges and opportunities where GenAI can add value, such as automating customer support or generating marketing content.
- **Industry-Specific Applications:** Each industry has unique AI requirements. For instance:
  - o **Healthcare:** AI-driven diagnostics must comply with HIPAA regulations. AI chatbots and automated healthcare assistants handling patient data must meet stringent security and privacy requirements under HIPAA. As highlighted by AI developers and vendors face challenges in ensuring data confidentiality, access control, and compliance monitoring. Failure to meet these standards can lead to legal repercussions and data breaches, emphasizing the need for robust security measures and compliance strategies.
  - o **Finance:** GenAI should align with Basel III compliance and anti-money laundering (AML) protocols.
  - o **Retail & E-commerce:** AI-powered personalization for enhanced customer engagement.
  - o **Cybersecurity:** AI models must detect and mitigate cyber threats efficiently.
- **Prioritization:** Rank use cases based on their potential business impact, feasibility of implementation, and resource availability, ensuring focus on high-value, low-complexity initiatives first.

8.3. Developing AI capabilities: a two-stage approach

The deployment of GenAI follows a phased approach to transition from experimentation to scalable implementation. This phased approach minimizes risks, builds confidence in GenAI, and supports gradual organizational adoption.

- **Initial Stage: Prototype and Proof of Concept (PoC)**
  o Use open-source tools like AutoGPT or AutoGen to rapidly prototype AI solutions.
  o Target simple, high-impact use cases, such as answering customer queries or summarizing documents.
  o Evaluate outcomes through testing and feedback, refining the strategy as needed to address gaps or limitations.
- **Second Stage: Scalable Deployment**
  o Leverage commercial platforms like LangGraph or CrewAI for larger, more complex deployments.
  o Integrate GenAI with existing systems, such as ERP or CRM platforms, to optimize workflows and enhance efficiency.
  o Continuously monitor performance to ensure scalability and alignment with business objectives [47].

8.4. Ensuring effective implementation

Successful GenAI deployment requires careful planning and collaboration. This ensures the strategy remains agile, responsive, and aligned with business needs.

- **Multidisciplinary Teams:** Assemble teams comprising developers, data scientists, business managers, and security experts to ensure technical, operational, and strategic alignment.
- **Project Management:** Use tools like Jira or Asana to track progress, manage timelines, and address bottlenecks.
- **Continuous Assessment:** Regularly evaluate user feedback, business outcomes, and technical performance to refine processes and adapt to challenges.

8.5. Addressing security and privacy

GenAI strategies must prioritize data protection and regulatory compliance to mitigate risks. These measures are essential to build trust and maintain the integrity of GenAI systems.

- **Data Security:** Implement encryption, authentication, and access controls to safeguard sensitive data.
- **Privacy:** Ensure compliance with regulations like GDPR and CCPA to protect user privacy and avoid legal risks.
- **Industry-Specific Security Challenges:**
  o **Finance:** AI-driven fraud detection must comply with PCI-DSS standards.
  o **Healthcare:** Ensure compliance with HIPAA when processing patient data.
  o **Cybersecurity:** AI models must be robust against adversarial attacks.
- **Security Testing:** Conduct penetration testing and threat assessments to evaluate system stability and address vulnerabilities.

8.6. Fostering innovation and communication

GenAI strategies should leverage external collaboration and transparency to drive innovation. This approach enhances the strategy's adaptability and positions the organization as a leader in AI innovation.

- **Open-Source Contribution:** Actively contribute to projects like AutoGPT to maximize the benefits of open-source tools and foster community-driven advancements.
- **Collaboration:** Partner with startups, developers, and innovative teams to access cutting-edge expertise and accelerate progress.
- **Industry Knowledge Sharing:** Organize AI summits, research collaborations, and training programs to ensure continuous learning and adaptation.

8.7. Monitoring and continuous improvement

To sustain long-term success, GenAI strategies require ongoing evaluation and refinement. This ensures the GenAI strategy remains dynamic and competitive.

- **Success Criteria:** Define clear metrics, such as increased efficiency, reduced costs, or improved customer satisfaction, to measure AI impact.
- **Continuous Feedback:** Collect input from users and teams to identify areas for improvement and optimize performance.
- **Adaptation:** Regularly update the strategy to align with technological advancements, market changes, and evolving business needs.
- **Future Trends:** Stay updated on emerging GenAI technologies, including multimodal AI and autonomous AI agents, to ensure long-term relevance.

8.8. Limitations and considerations

While GenAI offers significant opportunities, it also presents challenges, including potential errors in complex scenarios, high implementation costs, and the need for ongoing training and updates. Organizations must carefully manage these limitations by starting with pilot projects, investing in robust security, and maintaining human oversight where necessary. By combining a clear vision, prioritized use cases, a structured deployment process, and a focus on security, privacy, and continuous improvement, businesses can develop an effective GenAI roadmap. Embracing agile principles and adapting to change will ensure the organization fully leverages AI innovations while remaining competitive in the market [48].

9. Conclusion

Agentic artificial intelligence, particularly Generative AI (GenAI), holds immense potential to transform various industries by delivering autonomous, intelligent systems that enhance productivity, drive innovation, and improve customer experiences. This research has demonstrated that AI agents, characterized by autonomy, reactivity, proactivity, and learning ability, significantly impact organizational performance and competitiveness. Looking ahead, the future prospects of Agentic AI are promising yet complex. As AI technologies continue to evolve, we can expect advancements in multimodal capabilities, enabling agents to process and integrate diverse data types (e.g., text, images, audio, and video) with greater accuracy and context-awareness. The transition from "Copilot" to "Autopilot" models, as discussed, suggests a trajectory toward increasingly autonomous systems, reducing human intervention while raising new challenges related to trust, ethics, and oversight. Additionally, the integration of Agentic AI with emerging technologies like quantum computing and edge AI could unlock unprecedented scalability and real-time decision-making capabilities. However, realizing this potential will require addressing critical issues, such as privacy, data security, and the societal impact on the labor market, as well as fostering collaboration between industries, governments, and researchers. By embracing these opportunities and navigating the associated risks, organizations can position themselves at the forefront of an intelligent, AI-driven future.

9.1. Key findings of this research

- Artificial intelligence helps organizations save time, reduce operational costs, and increase productivity by automating routine and complex tasks.
- GenAI's multimodal capabilities enable the processing and combination of information from various sources (text, image, sound, and video), significantly improving user interactions.
- The hierarchical architecture in agent-based AI systems organizes, manages, and coordinates different agents, increasing overall system efficiency.
- The "Service as Software" (SaaS) model in agent-based AI allows outsourcing tasks and accessing specialized services at an affordable cost.
- The transition from "Copilot" to "Autopilot" models enhances autonomy in intelligent systems and reduces the need for human intervention.
- This research also examines the business needs of agent-based AI, introducing development tools like LangChain and CrewAI, and emphasizes the importance of formulating a comprehensive strategy for effective GenAI utilization, including selecting appropriate tools, training human resources, and managing risks.

9.2. Limitations of this research

The limitations of this research include the limited review of existing tools and the lack of case analysis in specific industries. Therefore, for future research, it is suggested to.

- Examine the effects of artificial intelligence in different industries in greater detail and with a case-by-case approach.
- Seriously consider the ethical and social aspects related to this technology, including issues of privacy, data security, and the impact on the labor market.

CRediT authorship contribution statement

Soodeh Hosseini: Writing – review & editing, Visualization, Supervision, Resources, Project administration, Investigation, Formal analysis, Conceptualization. **Hossein Seilani:** Writing – original draft, Visualization, Software, Resources, Methodology, Investigation, Data curation.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

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The authors declare that they have no conflict of interest.

Data availability

No data was used for the research described in the article.

References

[1] Siemon D, Strohmann T, Michalke S. Creative potential through artificial intelligence: recommendations for improving corporate and entrepreneurial innovation activities. Commun Assoc Inf Syst 2022;50(1):241–60. https://doi.org/10.17705/1CAIS.05009.

[2] Shiloh BE. Artificial intelligence as a powerful tool. Success is no accident. It is hard work, perseverance, learning, studying, sacrifice and most of all, love of what you are doing or learning to do, vol. 298; 2022.

[3] Cerrato G, Liu P, Zhao L, Petrazzuolo A, Humeau J, Schmid ST, Kroemer G. AI-based classification of anticancer drugs reveals nucleolar condensation as a predictor of immunogenicity. Mol Cancer 2024;23:275.

[4] Salybekova N, Issayev G, Serzhanova A, Mikhailov V. Utilizing artificial intelligence for cultivating decorative plants. Botanical Studies 2024;65:39. https://doi.org/10.1186/s40529-024-00445-9.

[5] Chan A, Ezell C, Kaufmann M, Wei K, Hammond L, Bradley H, Anderljung M. Visibility into AI agents. In: The 2024 ACM conference on fairness, accountability, and transparency; 2024, June. p. 958–73.

[6] Bostrom N, Yudkowsky E. The ethics of artificial intelligence. In: Artificial intelligence safety and security. Chapman and Hall/CRC; 2018. p. 57–69.

[7] Kaplan A, Haenlein M. Siri, Siri, in my hand: who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. Bus Horiz 2019;62(1):15–25. https://doi.org/10.1016/j.bushor.2018.08.004.

[8] Lin Z, Ma W, Lin T, Zheng Y, Ge J, Wang J, Klein J, Bissyande T, Liu Y, Li L. Open-source AI-based SE tools: opportunities and challenges of collaborative software learning. ACM Trans Software Eng Methodol 2024. https://doi.org/10.1145/3708529.

[9] Liu B, Mazumder S, Robertson E, Grigsby S. AI autonomy: self-initiated open-world continual learning and adaptation. AI Mag 2023;44(2):185–99. arXiv. https://arxiv.org/abs/2203.08994.

[10] Moawad A, Li Z, Pancorbo I, Gurumurthy KM, Freyermuth V, Islam E, Rousseau A. A real-time energy and cost efficient vehicle route assignment neural recommender system. Expert Syst Appl 2025;263:125634.

[11] Mohan S, Piotrowski W, Stern R, Grover S, Kim S, Le J, de Kleer J. A domain-independent agent architecture for adaptive operation in evolving open worlds. Artif Intell 2024:104161.

[12] Liu B, Robertson E, Grigsby S, Mazumder S. Self-initiated open world learning for autonomous AI agents. AI Magazine 2023;21:1–7.

[13] Singh A, Ehtesham A, Kumar S, Khoei TT. Enhancing AI systems with agentic workflows patterns in large language model. In: 2024 IEEE world AI IoT congress (AIIoT); 2024, May. p. 527–32. IEEE.

[14] Haj Qasem M, Aljaidi M, Samara G, Alazaidah R, Alsarhan A, Alshammari M. An intelligent decision support system based on multi agent systems for business classification problem. Sustainability 2023;15(14):10977.

[15] Makokha J. Enhancing Human-AI (H-AI) collaboration on design tasks using an interactive text/voice artificial intelligence (AI) agent. In: Proceedings of the 2022 international conference on advanced visual interfaces; 2022, June. p. 1–4. https://doi.org/10.1145/3531073.3534478.

[16] Hauff M, Lurz A. Agent-based models using artificial intelligence: a literature review. In: Proceedings of the Pacific Asia conference on information systems (PACIS) 2022. Association for Information Systems; 2022 (Paper 106).

[17] Krizhevsky A, Sutskever I, Hinton GE. Embedding methods for image search. In: ImageNet classification with deep convolutional neural networks; 2012. Retrieved from, https://www.pinecone.io/learn/series/image-search/imagenet.

[18] Sucholutsky I, Narayan A, Schonlau M, Fischmeister S. Pay attention and you won't lose it: a deep learning approach to sequence imputation. PeerJ Comput Sci 2019; 5:e210. https://doi.org/10.7717/peerj-cs.210.

[19] Ionescu Ș, Delcea C, Chiriță N, Nica I. Exploring the use of artificial intelligence in agent-based modeling applications: a bibliometric study. Algorithms 2024;17(1):21. https://doi.org/10.3390/a17010021.

[20] Al-Surmi A, Bashiri M, Koliousis I. AI-based decision making: combining strategies to improve operational performance. Int J Prod Res 2022;60(14):4464–86. https://doi.org/10.1080/00207543.2021.2006023.

[21] Dandale MN, Daniel DJJD, Priya R, Walid MAA, T T. Business process automation using robotic process automation (RPA) and AI algorithms on various tasks. In: 2023 International Conference on Computing, Communication, and Energy Systems (ICCES); 2023. p. 821–7. https://doi.org/10.1109/icces57224.2023.10192653.

[22] Bharadiya JP, Thomas RK, Ahmed F. Rise of artificial intelligence in business and industry. J Eng Res Rep 2023;25(3):85–103.

[23] Bhayana R, Fawzy A, Deng Y, Bleakney RR, Krishna S. Retrieval-augmented generation for large language models in radiology: another leap forward in board examination performance. Radiology 2024;313(1). https://doi.org/10.1148/radiol.241489.

[24] Vidivelli S, Ramachandran M, Dharunbalaji A. Efficiency-driven custom chatbot development: unleashing LangChain, RAG, and performance-optimized LLM fusion. Comput Mater Continua (CMC) 2024;80(2):2423–42. https://doi.org/10.32604/cmc.2024.054360.

[25] Koo T. Hierarchical system architecture for multi-agent multi-modal systems. Proceedings of the 40th IEEE Conference on Decision and Control 2023;2:1509–14. https://doi.org/10.1109/cdc.2001.981108.

[26] Gorodetsky VI, Kozhevnikov SS, Novichkov D, Skobelev PO. The framework for designing autonomous cyber-physical multi-agent systems for adaptive resource management. In: Industrial applications of Holonic and multi-agent systems: 9th international conference, HoloMAS 2019, Linz, Austria, August 26–29, 2019, Proceedings, vol. 9. Springer International Publishing; 2019. p. 52–64.

[27] Mařík V, Kadera P, Rzevski G, Zoitl A, Anderst-Kotsis G, Tjoa AM, Khalil I, editors. Industrial applications of Holonic and multi-agent systems: 9th international Conference, HoloMAS 2019, Linz, Austria, August 26–29, 2019, Proceedings, vol 11710. Springer; 2019.
[28] Mathew D, Brintha NC, Jappes JW. Artificial intelligence powered automation for industry 4.0. In: New horizons for industry 4.0 in modern business. Cham: Springer International Publishing; 2023. p. 1–28.
[29] Kaplan S, Haenlein M. Siri, Siri, in my hand: who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. Bus Horiz 2019;62(1):15–25. https://doi.org/10.1016/j.bushor.2018.08.004.
[30] Adebiyi AA, Apeh F, Olaniyan J, Adebiyi MO, Olaniyan D, Oluwasegunfunmi IB, Akindeji K. Automating customer service using Natural Language Processing. In: 2024 international Conference on science, engineering and business for driving sustainable development goals (SEB4SDG); 2024, April. p. 1–8. IEEE.
[31] Pisarov J, Mester G. Implementing new mobility concepts with autonomous self-driving robotic cars. IPSI Transac Adv Res (TAR) 2021;17(2):41–9.
[32] Islam MM. Autonomous systems revolution: exploring the future of self-driving technology. J Artificial Intelligence General Science (JAIGS) ISSN: 3006-4023 2024;3(1):16–23.
[33] Lewandowski N, Koller B. Transforming medical sciences with high-performance computing, high-performance data analytics and AI. Technol Health Care 2023;31 (4):1505–7.
[34] Khanna NN, Maindarkar MA, Viswanathan V, Fernandes JFE, Paul S, Bhagawati M, Suri JS. Economics of artificial intelligence in healthcare: diagnosis vs. treatment. Healthcare, vol. 10. MDPI; 2022, December. p. 2493. 12.
[35] Holzinger A, Langs G, Denk H, Zatloukal K, Müller H. Causability and explainability of artificial intelligence in medicine. Wiley Interdisciplinary Reviews: Data Min Knowl Discov 2019;9(4):e1312. https://doi.org/10.1002/widm.1312.
[36] Amershi S, Weld DS, Vorvoreanu M, Fourney A, Nushi B, Collisson P, Horvitz E. Guidelines for human-AI interaction. Proceedings of the 2019 CHI conference on human factors in computing systems. 2019. p. 1–13. https://doi.org/10.1145/3290605.3300233.
[37] Seeber I, Bittner E, Briggs RO, de Vreede T, de Vreede GJ, Elkins A, Weber B. Machines as teammates: a research agenda on AI in team collaboration. Inf Manag 2020;57(2):103174. https://doi.org/10.1016/j.im.2019.103174.
[38] Li T, Sahu AK, Talwalkar A, Smith V. Federated learning: challenges, methods, and future directions. IEEE Signal Process Mag 2020;37(3):50–60. https://doi.org/10.1109/MSP.2020.2975749.
[39] Beulen E, Plugge A, van Hillegersberg J. Formal and relational governance of artificial intelligence outsourcing. Inf Syst E Bus Manag 2022;20(4):719–48.
[40] Grand View Research. Artificial intelligence market size, share, growth report 2030. https://www.grandviewresearch.com/industry-analysis/artificial-intelligence-ai-market; 2024.
[41] MarketsandMarkets. Artificial intelligence market size, share & trends – 2033. https://www.marketsandmarkets.com/Market-Reports/artificial-intelligence-market-100812355.html; 2024, May 30.
[42] Statista. Artificial intelligence (AI) market size worldwide from 2020 to 2024, November 27:2030. https://www.statista.com/forecasts/1474143/global-ai-market-size.
[43] Lu Y, Aleta A, Du C, Shi L, Moreno Y. LLMs and generative agent-based models for complex systems research. Phys Life Rev 2024, 51:283-293.
[44] Lok KL, So A, Opoku A, Chen C. A sustainable artificial intelligence facilities management outsourcing relations system: case studies. Front Psychol 2022;13: 920625. https://doi.org/10.3389/fpsyg.2022.920625.
[45] Nguyen ST, Tulabandhula T. Generative AI for business strategy: using foundation models to create business strategy tools. arXiv preprint arXiv:2308.14182 2023. https://doi.org/10.48550/arXiv.2308.14182.
[46] Rezaei Khonakdar D. AI chatbots and challenges of HIPAA compliance for AI developers and vendors. J Law Med Ethics 2023;51(4):988–95.
[47] Easin AM, Sourav S, Tamás O. An intelligent LLM-powered personalized assistant for digital banking using LangGraph and Chain of Thoughts. In: 2024 IEEE 22nd jubilee international symposium on intelligent systems and informatics (SISY). IEEE; 2024, September. p. 625–30. https://doi.org/10.1109/SISY62279.2024.10737601.
[48] Perumal Venkadesh, Divya SV, Kumar K. Unlocking AI creativity: a multi-agent approach with CrewAI. J Trends in Computer Sci Smart Technol 2024;6:338–56. https://doi.org/10.36548/jtcsst.2024.4.002.