COLUMN: AI FOCUS

The Rise of Agentic Al: Implications, Concerns, and the Path Forward

San Murugesan[®], BRITE Professional Services, Sydney, NSW, 2152, Australia

Agentic artificial intelligence (AI) represents a transformative leap in AI, evolving beyond reactive systems to autonomous, goal-oriented agents capable of learning, adapting, and making independent decisions. As it presents immense opportunities, its adoption is growing across industries. However, its rise introduces critical challenges. Responsible adoption requires robust governance, transparency, and a well-defined regulatory framework. This article explores agentic AI's defining characteristics, real-world applications, and transformative potential, and examines its societal and business implications. To shape agentic AI as a trusted, transformative force for responsible innovation and meaningful progress, we propose research directions and offer stakeholder recommendations.

gentic artificial intelligence (AI) represents a transformative advancement in AI, garnering significant attention from technology leaders, researchers, businesses, and end users. Unlike traditional AI, which primarily responds to predefined inputs, agentic AI operates autonomously with minimal human intervention. It exhibits proactivity, adaptability, and goal-oriented behavior, continuously optimizing its actions to achieve specified objectives.

Agentic AI systems possess multiple capabilities, including processing information, planning, and decision making, recalling and reflecting on past interactions, collaborating dynamically, leveraging diverse online tools, and executing appropriate actions. These capabilities enable agentic AI to drive innovation, enhance automation, foster Al-human collaboration, and transform industries across various domains.

Agentic Al's independence and broader functionality in handling complex tasks set agentic Al apart from simpler Al agents. Agentic Al anticipates needs, learns from new experiences, and proactively refines its strategies to achieve its objectives. These capabilities make

agentic AI an intelligent partner to humans in performing complex tasks. As Microsoft CEO Satya Nadella has remarked, "AI agents will become the primary way we interact with computers in the future. They will be able to understand our needs and preferences and proactively help us with tasks and decision making."²³

While generative AI is reshaping content creation and problem-solving, agentic AI is poised to redefine how machines think and act independently: enhancing efficiency, productivity, and human-machine collaboration. Its potential applications span a wide range of areas.

According to Gartner, by 2028, 33% of enterprise applications will incorporate agentic AI, a significant increase from less than 1% in 2024. A Cappemini report highlights that while only 10% of companies currently employ AI agents, an overwhelming 82% plan to integrate them within the next three years. Deloitte further predicts that one-fourth of early adopters will implement AI agents by 2025. Furthermore, with investments in AI technologies projected to surpass \$749 billion by 2028, the transformative potential of agentic AI is evident.

However, like any disruptive technology, agentic Al presents both opportunities and challenges. While it offers groundbreaking capabilities, it also raises concerns related to trust, security risks, ethical dilemmas, malfunctions, and potential job displacement. Ensuring its responsible development, deployment, and use

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requires a good understanding of its capabilities, limitations, and broader societal and business impacts.

In this article, we explore agentic Al's unique characteristics, architecture, and applications and examine its implications and challenges. We also outline potential research directions for advancing agentic Al and the roles of key stakeholders in shaping the future of agentic Al and its responsible adoption.

AGENTIC AI

Unlike traditional AI models that merely respond to prompts or execute predefined tasks, agentic AI possesses decision-making, planning, and learning capabilities that enable it to operate autonomously in pursuit of user-defined objectives. Rather than performing isolated tasks, agentic AI can take initiative, solve complex multistep problems, and adapt dynamically to changing circumstances.

A defining feature of agentic AI is its "chaining" capability: the ability to sequence multiple actions in response to a single request autonomously. This feature allows the system to break down complex tasks into smaller, manageable steps while continuously refining its approach. Agentic AI can independently navigate multistep problem-solving through advanced reasoning and iterative planning. For example, when tasked with creating a website, an agentic AI system would generate a structured series of subgoals—such as designing the layout, selecting appropriate content, and optimizing for user experience—and then autonomously work toward achieving them.

The Architecture of Agentic Al

Agentic AI systems are composed of several interconnected components:

- Perception: Sensors and input mechanisms collect data from the surrounding environment.
- Cognitive processing and decision making: The system analyzes data, evaluates potential courses of action, and selects the most optimal strategy.
- Action execution: The agent precisely carries out chosen actions, facilitating real-world interaction.
- Continuous learning: Agentic AI employs advanced learning paradigms—including supervised, unsupervised, and reinforcement learning—to continuously refine its performance, adapt to new information, and improve over time.

The Four-Step Process of Agentic Al

Agentic AI follows a structured four-step process to complete tasks autonomously⁵:

- Perceive: Al agents gather and process data from multiple sources, such as sensors, databases, and digital interfaces. This process involves feature extraction, object recognition, and the identification of relevant entities in the environment.
- 2) Reason: A large language model functions as the core reasoning engine, orchestrating specialized Al models for distinct tasks, such as content generation, visual processing, or recommendation systems. This step often employs retrieval-augmented generation techniques to access proprietary data sources and generate accurate, contextually relevant outputs.
- 3) Act: By integrating with external tools and software via application programming interfaces, agentic AI executes tasks based on its formulated plans. Built-in guardrails ensure task execution aligns with predefined constraints. For example, a customer service AI agent may autonomously process claims up to a certain threshold, while higher-value claims require human approval.
- 4) Learn: Agentic Al continuously improves through a feedback loop, often referred to as the "data flywheel," where insights from previous interactions refine its models. This self-improvement mechanism enhances decision making, operational efficiency, and long-term effectiveness.

An example of agentic AI in action is OpenAI's Operator, ⁶ its first AI agent capable of executing tasks directly from a web browser. Powered by the computer-using agent model, the Operator autonomously breaks tasks into structured plans, self-corrects errors, and incorporates safeguards against harmful or illegal activities. By combining GPT-4o's vision capabilities with advanced reasoning, it can interact with websites in a human-like manner: navigating, clicking, typing, and executing tasks without requiring specialized integrations.

For further information on agentic AI, refer to a recent survey article⁷ and a guide⁸ that provides a comprehensive overview of agentic AI. Additionally, another study⁹ explored an agentic agent-based multiagent framework for recommender systems, highlighting the potential of these AI models in decision-support applications.

TRANSFORMATIVE APPLICATIONS OF AGENTIC AI

Agentic AI is already significantly having an impact across diverse sectors, including autonomous vehicles, manufacturing, health care, ¹⁰ finance, defense, ¹¹ smart homes, smart cities, and customer service. ¹² By automating complex tasks, enhancing decision

making, and driving operational efficiency, agentic Al is poised to revolutionize several industries.^{13,14} Key areas of impact include:

- Business operations: Al agents autonomously manage supply chains, optimize inventory, forecast demand, and streamline logistics, leading to increased efficiency and cost reduction.
- Health care: Al-driven virtual assistants continuously monitor patient health, adjust treatments in real time, and predict potential medical issues, facilitating proactive care and improved patient outcomes.
- Software development: Agentic AI has the potential to oversee the entire software development lifecycle, from designing architectures and generating code to debugging and quality assurance. By 2030, Al-driven automation could account for up to 30% of work hours, allowing developers to focus on complex challenges and innovation.¹⁵
- Cybersecurity: AI systems can monitor network activity, detect anomalies, and autonomously respond to cyber threats, strengthening organizational security while enabling human experts to address more sophisticated security challenges.
- Human resources: Al-powered tools streamline candidate screening, interview scheduling, employee onboarding, and personalized career development, improving efficiency and reducing administrative burdens.
- Scientific research: Agentic AI can autonomously design experiments, analyze complex datasets, and generate novel hypotheses, accelerating discoveries in pharmaceuticals, materials science, and other research domains.
- > Finance: Al agents analyze market trends, execute trades, and adjust investment strategies in real-time, optimizing portfolio management and enhancing market efficiency.
- Customer service: Al-driven virtual assistants transform customer support by automating routine inquiries and improving self-service capabilities. More than half of service professionals report significant improvements in customer interactions, including reduced response times and increased satisfaction.¹⁶ Additionally, the emergence of digital humans¹⁷—Al-powered agents designed to provide lifelike, real-time interactions—offers new sales and customer engagement possibilities, particularly in high-volume service environments.

Early implementations of agentic Al delineate a three-tiered agentic Al value pyramid—augmentation,

automation, and ideation—each representing a distinct level of value creation.¹⁸ By integrating Al-driven autonomy across industries, agentic Al is redefining traditional workflows, enhancing productivity, and driving innovation at an unprecedented scale.

Redefining Work and Workforce Roles

As agentic Al increasingly automates routine and semicomplex tasks, the nature of work and workforce roles will undergo significant transformation.¹⁹ Employees will require upskilling to understand agentic Al's capabilities and limitations and embrace its potential. Expertise in Al oversight, strategy formulation, and problem-solving will become essential as human workers shift toward higher-level decision making and Al governance.

Furthermore, the collaboration between humans and agentic AI systems²⁰ will necessitate cross-functional skills, as employees learn to integrate AI into existing workflows. Organizations must invest in employee reskilling initiatives to ensure a smooth transition, fostering a workforce that can harness agentic AI's full potential while mitigating its risks.

ADDRESSING THE CHALLENGES OF AGENTIC AI

Despite its transformative potential, agentic AI presents several challenges, including transparency, safety, security and data privacy concerns, labor market disruptions, and regulatory complexities. The successful implementation of agentic AI and the realization of its full potential require addressing the following critical challenges:

- > Ethical considerations: Fairness, transparency, and accountability in AI decision making are paramount. Developing robust ethical frameworks and governance mechanisms is essential to aligning AI systems with societal values and mitigating biases. A key concern that continues to be a focal point in AI ethics research is how biases can be minimized and equitable outcomes can be ensured.
- Security risks: Agentic AI systems are vulnerable to cyber threats, including adversarial attacks and data breaches. Implementing robust security measures—such as encryption, secure coding practices, anomaly detection, and continuous monitoring—is crucial to safeguarding agentic AI applications.
- Development complexity: The development of agentic AI involves intricate system architectures and advanced machine learning models.

Adopting modular designs, reusable components, and automated development tools is essential to streamline implementation and reduce complexity.

- > Transparency and accountability: The "black box" nature of AI decision making complicates interpretability and raises concerns about accountability, particularly in high-stakes applications. A fundamental question remains: Who bears responsibility when agentic AI makes an error or cause harm?²¹ This issue is central to ongoing discussions on AI governance.
- Data privacy and security: As AI systems increasingly handle sensitive information, ensuring robust data protection measures is imperative. Strong privacy safeguards, regulatory compliance, and privacy-preserving and secure data-handling practices are necessary to prevent misuse and breaches.
- > Workforce disruption: While Al-driven automation enhances productivity and creates new opportunities, it challenges the labor market. Workforce adaptation through reskilling and lifelong learning will be essential to manage job displacement and support.
- Model reliability and safety: Preventing misuse and ensuring control over agentic AI systems requires careful oversight. Establishing comprehensive guardrails, including fail-safe mechanisms, ethical constraints, and continuous monitoring, is essential to ensuring their responsible deployment and use. Without proper safeguards, these systems may behave unpredictably leading to unintended consequences.
- Risk alignment in agentic AI systems: Managing risks associated with advanced AI is among the most pressing challenges of our time.²² Agentic AI systems introduce three primary categories of risk:
 - Systemic risks: Labor market disruptions, economic shifts, and widespread job displacement resulting from Al-driven automation are some of the systemic risks.
 - Malfunction and out-of-control risks: Agentic
 Al systems may exhibit unintended or harmful
 behaviors, raising concerns about their reliable and safe operation.
 - Misuse risks: Malicious actors may exploit agentic Al's capabilities for unethical purposes, including cyber threats, misinformation campaigns, and automated warfare.

Addressing these challenges is critical to ensuring agentic Al's responsible and effective deployment and use in real-world applications. Building public trust

and maximizing Al's benefits requires a proactive approach, balancing innovation with ethical safeguards. Therefore, in parallel with technological advancements, stakeholders must define the ethical boundaries and governance and audit frameworks that will shape the future of agentic Al and its applications.

THE RISE OF AGENTIC AI

The increasing interest in agentic AI stems from its transformative potential in reshaping human-technology interactions and addressing complex problems. Agentic AI's autonomy, adaptability, and goal-driven behavior capabilities are a disruptive force across industries. Its ability to operate with minimal human intervention while dynamically responding to changing environments appeal is an added attraction.¹³

Key agentic Al's characteristics that appeal to developers and users include:

- Enhanced autonomy: Agentic AI systems function with minimal human oversight, making them well-suited for tasks that require continuous monitoring, rapid decision making, and real-time adaptability.
- Advanced problem-solving: By integrating machine learning with goal-directed behavior, agentic AI can analyze complex problems, generate and execute solutions, and optimize decision-making processes.
- Dynamic adaptability: Agentic AI continuously refines its strategies based on new data and evolving environmental conditions, enhancing resilience and effectiveness in unpredictable scenarios.
- Personalized experiences: Agentic Al continuously learns from user interactions to deliver highly tailored solutions that improve engagement, decision support, and user satisfaction.
- Scalability across industries: Once trained, these systems can be deployed seamlessly across multiple domains, accelerating innovation and adoption.
- Natural language proficiency: Agentic AI exhibits advanced language comprehension, allowing it to interpret human intent, clarify expectations, engage in discussions, and demonstrate reasoning, making human—AI interactions more intuitive and productive.

As agentic Al continues to evolve, its potential to drive efficiency, foster innovation, and enable intelligent automation will redefine the role of Al in both industry and everyday life. Its widespread adoption is poised to unlock new opportunities while presenting challenges that require careful consideration.

FUTURE DIRECTIONS FOR AGENTIC AI

Looking ahead, staying informed about advancements in agentic AI is crucial to preparing for the transformative shifts they will bring. By examining expert insights and harnessing the capabilities of these intelligent systems, we can lead the way in shaping a future where AI-driven innovation enhances autonomy, productivity, convenience, and human purpose.

Further Research and Development

The evolution of agentic AI and its widespread adoption will be driven by advances in research and development in several key areas, including:

- Efficient learning: Advanced learning techniques, such as few-shot learning and transfer learning, will reduce data dependency, enabling faster, more adaptive AI deployment.
- Technological integration: The convergence of AI, the Internet of Things, and blockchain will create interconnected, resource-efficient systems capable of tackling complex real-world challenges.
- Human-Al collaboration: Developing intuitive interfaces and explainable Al will enhance trust and make human-Al partnerships more seamless and productive.
- Ethical and transparent AI: Ensuring transparency, ethical alignment, and adherence to human values will be critical in fostering responsible AI adoption and public trust.
- Multiagent systems: Agentic AI will increasingly collaborate with multiple autonomous agents, enhancing problem-solving capabilities and task execution in distributed environments.

Agentic AI can move toward a future fostering responsible technological progress by prioritizing advancements in these and other related areas.

The Role of Agentic AI in Scientific Discovery

Agentic AI has the potential to accelerate breakthroughs in scientific discovery by autonomously designing and conducting experiments, analyzing results, or formulating new hypotheses. These AI-driven agents could dramatically enhance the pace of innovation across various scientific disciplines, including pharmaceutical drug discovery and the development of new materials.

For example, OpenAI has introduced Deep Research, an advanced AI agent capable of conducting complex, multistep online research across diverse domains, such as scientific studies, personalized recommendations, and emerging business or technology trends. Powered by an optimized version of OpenAI's o3 reasoning model, Deep Research can rapidly search and analyze vast amounts of text, images, and PDFs to generate comprehensive research reports, accelerating knowledge dissemination and discovery and decision making.

Agentic Al's ability to quickly generate research outputs also raises concerns about misuse. Bad actors could exploit the same speed and efficiency that enable legitimate scientific advancements to produce misleading or low-quality reports for personal gain or societal harm. Addressing such risks will require robust oversight mechanisms, verification protocols, and ethical guidelines to ensure that agentic Al is deployed and used responsibly.

As agentic AI advances, its impact on research, industry, and daily life will be profound. By investing in developing ethical frameworks, transparent methodologies, and collaborative AI-human partnerships, we can ensure that this technology serves as a force for progress while mitigating potential risks.

CALL TO ACTION: RECOMMENDA-TIONS FOR STAKEHOLDERS

The responsible development and deployment of agentic AI require proactive engagement from key stakeholders that fosters safety, ethical integrity, and societal benefit. The following recommendations outline critical actions for various stakeholders:

- Governments and policymakers: Establish adaptive regulatory and governance frameworks that evolve alongside AI advancements. Support research into AI ethics and safety, including liability and accountability mechanisms. Foster cross-border collaboration to harmonize AI laws and standards, ensuring a consistent global approach. Advocate for transparent AI policies safeguarding privacy, human autonomy, and public trust.
- Industry leaders: Prioritize investments in Al safety research, including developing robust guardrails. Collaborate on creating industry-wide standards and protocols to enhance transparency and accountability. Develop frameworks for the safe and ethical deployment and use of agentic Al, incorporating human oversight to

- ensure responsible adoption. Strategically integrate agentic AI into organizational information systems and operational processes to maximize its potential while mitigating risks.
- Developers: Focus on designing AI systems with explainability, bias mitigation, and built-in ethical safeguards. Prioritize transparency and fairness in AI decision making to foster trust and accountability.
- Researchers: Carry out agentic AI research that matters and address the current limitations and concerns. Conduct interdisciplinary studies bridging AI development, ethics, and law. Investigate the socioeconomic implications of autonomous systems, including their impact on employment, equity, and governance.
- Academia and professional associations: Promote awareness of agentic Al's capabilities and risks within the scientific and professional communities. Integrate ethical Al design principles into computer science, engineering, business, and law curricula. Expand Al literacy programs to prepare future generations for Al-driven work environments and offer professional development initiatives focused on Al governance, human–Al collaboration, and human oversight.

Stakeholders must take decisive proactive action now to ensure that the development and deployment of agentic AI align with ethical principles and societal well-being. By fostering collaboration across disciplines, sectors, and borders, we can guide the responsible evolution of agentic AI for the benefit of humanity.

SUMMING UP

Agentic AI is rapidly emerging as a transformative force in AI, ushering in a shift toward systems capable of acting autonomously, adapting in real time, and solving complex, multistep problems. Its evolution hinges on how effectively we address its challenges and limitations.

Far beyond a mere tool, agentic AI has the potential to become an active collaborator, fundamentally reshaping human–machine interaction and nature of work. While generative AI has already revolutionized content creation, agentic AI expands the scope of autonomy in decision making, learning, and execution. Its continued advancement and meaningful application require responsible stewardship, with a strong focus on functional accuracy, transparency, trust, and ethical alignment, ensuring these systems ultimately serve humanity's best interests.

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SAN MURUGESAN is with BRITE Professional Services, Sydney, NSW, 2152, Australia. Contact him at san@computer.org.

