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Comprehensive Review of Artificial General Intelligence AGI, Agentic AI and GenAI: Current Trends and Future Directions

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Abstract
This paper presents a comprehensive review of Artificial General Intelligence (AGI) and Agentic AI, examining their technological foundations, current capabilities, and future trajectories. The study identifies key technical distinctions between these AI paradigms, including their architectural requirements, computational demands, and learning mechanisms. We survey the current technical landscape, including specialized frameworks like OpenAI's AGI classification system and emerging Agentic AI platforms such as Vectara-agentic and CrewAI. The paper also examines the hardware infrastructure and cloud services enabling these advanced AI systems, from NVIDIA's specialized GPUs to large-scale projects like OpenAI's proposed "Stargate" initiative and others. Our comparative analysis reveals that Agentic AI is rapidly transitioning from research to practical deployment across industries including legal services, DevOps, and enterprise automation, while AGI remains in the research phase with ongoing debates about its feasibility and timeline. The paper discusses critical challenges in both domains, including safety considerations, alignment problems, and governance requirements. We highlight how Agentic AI serves as a bridge between today's generative AI capabilities and future AGI aspirations, offering autonomous functionality while avoiding some of AGI's unresolved risks.

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1. Introduction
The field of artificial intelligence is undergoing rapid transformation, with two particularly significant developments capturing researchers' attention: the pursuit of Artificial General Intelligence (AGI) and the emergence of Agentic AI systems [1, 2]. While AGI represents the long-standing goal of creating machines with human-level general intelligence [3], Agentic AI focuses on developing autonomous systems capable of complex decision-making within specific domains [4]. Recent advancements have reignited debates about the feasibility and timeline for achieving AGI. Some experts predict AGI could emerge as early as 2025 [5, 6], while others remain skeptical, arguing that fundamental challenges remain unresolved [7, 8]. Meanwhile, Agentic AI has gained traction as a practical approach to creating more autonomous and capable AI systems [9, 10]. This paper examines the current state of both AGI and Agentic AI, their relationship, and their potential impacts on industry and society. Section II explores definitions and key concepts. Section III analyzes recent technological developments. Section IV discusses challenges and limitations. Section V examines applications and implications, and Section VI concludes with future directions.

2. Introduction to Technical Concepts and Terminology
This section defines and explains more technical terms and concepts identified in the reviewed literature.

A) Definitions and Key Concepts

1. Artificial General Intelligence (AGI)

AGI refers to artificial intelligence systems that possess the ability to understand, learn, and apply knowledge across a wide range of tasks at a level comparable to human intelligence [3, 11, 58]. Unlike narrow AI systems designed for specific tasks, AGI would demonstrate flexible, general-purpose intelligence [12].

The pursuit of AGI represents what some consider the "holy grail" of AI research [13]. However, significant debate persists about both the definition of AGI and the path to achieving it [14].

2. Agentic AI

Agentic AI represents a paradigm shift from passive AI systems to autonomous agents capable of initiating actions, making decisions, and completing complex workflows without constant human supervision [2, 15]. These systems go beyond generative AI capabilities by incorporating goal-directed behavior and functional autonomy [4, 16].

Key characteristics of Agentic AI include

- Autonomous decision-making capabilities [17]
- Ability to handle multi-step workflows [18]
- Capacity for self-improvement within defined parameters [19]
- Contextual understanding and adaptation [20]

B) Technical Concepts and Terminology

1. Artificial General Intelligence (AGI): Systems with human-level understanding and reasoning across diverse domains [3]. Characterized by:

$$C_{AGI} = \sum_{i=1}^{n} (T_i \times A_i)$$

Where C_{AGI} represents general capability, T_i is task performance, and A_i is adaptation speed.

2. Agentic AI: Autonomous systems capable of goal-directed behavior and multi-step workflows [2]. Autonomous systems capable of goal-directed behavior and multi-step workflows [2]. Key components include function calling architectures, workflow orchestration engines, and reinforcement learning from human feedback (RLHF).

Key components include

- Function calling architectures
- Workflow orchestration engines
- Reinforcement learning from human feedback (RLHF)

3. Multi-Paradigmatic AI: Hybrid approaches combining neural networks with symbolic reasoning [21]. Expressed as:

$$M_{hybrid} = \alpha N_{neural} + (1 - \alpha) S_{symbolic}$$

4. Episodic Memory in AI: Biologically-inspired memory systems enabling contextual learning [22]. Biologically-inspired memory systems enabling contextual learning [22]. Implementations include differentiable neural computers (DNCs) and memory-augmented neural networks (MANNs).

Implemented through

- Differentiable neural computers (DNCs)
- Memory-augmented neural networks (MANNs)

5. Level AGI Classification: OpenAI's framework for measuring progress toward AGI [23]:

- Level 1: Basic conversational AI
- Level 2: Competent assistants
- Level 3: Autonomous agents
- Level 4: Innovating systems
- Level 5: Superintelligence

6. Agentic RAG: Retrieval-Augmented Generation systems with autonomous capabilities [24]. Architecture includes:

$$RAG_{agentic} = \Phi(Q) \oplus \Psi(D) \rightarrow A$$

Where Φ processes queries, Ψ handles documents, and A generates actions.

7. Function Calling: Critical capability enabling Agentic AI to interact with external systems [4]. A critical capability enabling Agentic AI to interact with external systems [4], implemented through API orchestration layers and tool-use architectures.

Implemented through

- API orchestration layers
- Tool-use architectures

8. **Autonomous DevOps**: Application of Agentic AI to continuous integration/deployment [10]. Key metrics:

$$\tau_{resolution} = \frac{\sum Incident_{complexity}}{\sum Agent_{capability}}$$

9. Neuro-Symbolic Integration: Combining neural networks with symbolic AI for AGI [21]. Represented as:

$$NS_{integration} = \sigma(NN) \times \lambda(KA)$$

10. AI Safety Benchmarks: Metrics for evaluating dangerous capabilities in advanced AI [25].Metrics for evaluating dangerous capabilities in advanced AI [25], including self-improvement potential, goal misalignment risk, and deception capabilities.

Critical dimensions include

- Self-improvement potential
- Goal misalignment risk
- Deception capabilities

These concepts represent the foundational technical vocabulary emerging from current AGI and Agentic AI research. Their continued development will shape the evolution of advanced AI systems in coming years. This work is a buildup of our previous work [59-73].

3. Recent Technological Developments

A) AGI Progress and Benchmarks

OpenAI has proposed a 5-level framework for measuring progress toward AGI, with current systems estimated to be at

Level 1 [23, 26]. The company has also developed new benchmarks to assess AGI potential and associated risks [25]. Recent research has explored multi-paradigmatic approaches to AGI development [21], including the incorporation of episodic memory systems inspired by human cognition [22]. Meanwhile, some organizations are moving away from the term AGI due to its controversial nature [27].

B) Agentic AI Advancements

Agentic AI systems are demonstrating increasingly sophisticated capabilities in various domains:

- DevOps and Kubernetes management [10]
- Legal services and document analysis [28]
- Retail and commerce applications [29]

Enterprise automation and workflow management [30]
Frameworks like Vectara-agentic are enabling the development of Agentic RAG (Retrieval-Augmented Generation) applications [24], while platforms like crewAI are facilitating collaborative AI agent systems [31].

C) Industry Adoption and Investment

Major technology companies are investing heavily in both AGI research and Agentic AI applications. OpenAI has outlined an ambitious path toward superintelligence while maintaining nonprofit oversight [32], [33]. Deloitte surveys indicate growing enterprise interest in Agentic AI solutions [34], with some experts viewing it as a more practical near-term focus than AGI [35].

4. Technical Landscape: Tools, Libraries, and Infrastructure

The rapid evolution of Artificial General Intelligence (AGI) and Agentic AI has spurred the emergence of a diverse technical ecosystem encompassing specialized frameworks, libraries, and infrastructure. This section surveys the current landscape, drawing on recent literature and industry developments.

A) Frameworks and Libraries for AGI Development

AGI research is supported by a suite of advanced frameworks and libraries:

- **OpenAI's Ecosystem:** The GPT architecture series (e.g., GPT-4 and successors) forms a foundation for AGI research, with tools like the GPT-4 API and ChatGPT's Operator Mode enabling experimentation with increasingly general capabilities [36], [37].
- **DeepMind's Symphony:** DeepMind integrates TensorFlow, JAX, and proprietary architectures such as those used in AlphaFold, advancing AGI-oriented research through a multi-framework approach [38].
- **Hybrid and Neuro-Symbolic Approaches:** Recent progress includes hybrid architectures that combine neural networks with symbolic reasoning, supported by libraries such as PyTorch Geometric and DeepGraphLibrary [21]. Memory-augmented systems leverage tools like FAISS for episodic memory [22].

B) Agentic AI Toolkits and Platforms

Agentic AI emphasizes autonomous, goal-directed systems, leading to new categories of toolkits:

- **Vectara-agentic:** A Python package designed for building agentic Retrieval-Augmented Generation (RAG) applications, featuring built-in orchestration and autonomy [24].
- **CrewAI:** An open-source framework supporting the creation of collaborative AI agents with role specialization and task delegation [31].
- **AutoGen:** Developed by Microsoft, AutoGen enables the construction of complex multi-agent conversational systems, supporting customizable agent behaviors.
- **AgentGPT:** A browser-based platform for deploying autonomous agents capable of dynamic goal-setting and execution.
- **Synechron's Agentic Stack:** A proprietary platform that combines large language models (LLMs) with function calling and workflow automation [4].

C) Cloud Services and Deployment Infrastructure

Major cloud providers are instrumental in supporting both AGI and Agentic AI workloads:

- **AWS Bedrock:** Offers access to foundation models and agentic workflow tools, including Agents for Amazon Bedrock.
- **Microsoft Azure AI Studio:** Provides orchestration capabilities for multi-agent systems and seamless integration with cognitive services.
- **Google Cloud Vertex AI:** Enables custom model training with TPU acceleration and supports agentic workflow pipelines.
- **NVIDIA AI Foundations:** Delivers generative AI models and agentic tools as cloud services, leveraging advanced hardware such as the H100 and B100 GPUs [18].
- **Specialized Hardware:** Research systems increasingly utilize high-end accelerators (e.g., NVIDIA H100/B100, Cerebras Wafer-Scale Engines, SambaNova dataflow units) to meet the computational demands of AGI and agentic workloads.

D) Computational Requirements and Hardware

The development and deployment of advanced AI systems require significant computational infrastructure:

- **Training Infrastructure:** Large-scale AGI experiments rely on GPU/TPU clusters with high-speed interconnects (e.g., NVLink, InfiniBand). Projects like OpenAI's "Stargate" envision massive, dedicated AI infrastructure [39].
- **Edge Deployment:** Agentic AI is increasingly deployed on edge devices using frameworks such as TensorRT-LLM for optimized inference on platforms like NVIDIA Jetson.
- **Quantum Hybrid Approaches:** Some research explores quantum-classical hybrid systems for specific AGI components, utilizing platforms like IBM Quantum and Amazon Braket.
- **Energy Efficiency:** New architectures emphasize power efficiency via mixture-of-experts (MoE) models and sparsity techniques [40].

E) Benchmarking and Evaluation Tools

Measuring progress in AGI and Agentic AI requires robust benchmarking tools:

- **OpenAI's AGI Levels:** A five-level classification system for tracking AGI progress [23].
- **Agentic Capability Metrics:** Frameworks such as

Outshift's 5 Levels of Agentic AI Intelligence offer enterprise-focused evaluation criteria [9].

- **AGI Safety Benchmarks:** New evaluation suites assess dangerous capabilities and alignment properties [25].
- **Multi-Agent Testing Environments:** Platforms like NetHack and Minecraft provide rich, interactive environments for testing agentic behaviors [19].

F) Frameworks and Libraries for AGI Development

The pursuit of AGI has driven the development of several specialized frameworks and libraries:

- **OpenAI's Ecosystem**: The GPT architecture series (including GPT-4 and beyond) serves as foundational models for AGI research [36]. OpenAI has released tools like the GPT-4 API and ChatGPT's Operator Mode as stepping stones toward AGI [37].
- **DeepMind's Symphony**: DeepMind employs a combination of TensorFlow, JAX, and proprietary frameworks like AlphaFold's architecture for AGI-oriented research [38].
- **Multi-Paradigm Approaches**: Recent work explores hybrid architectures combining neural networks with symbolic reasoning systems [21]. Frameworks like PyTorch Geometric and DeepGraphLibrary enable graph-based reasoning.
- **Memory Architectures**: Systems implementing episodic memory use modified versions of FAISS (Facebook AI Similarity Search) and specialized memory networks [22].

G) Agentic AI Toolkits and Platforms

Agentic AI development has spawned specialized tooling ecosystems:

- **Vectara-agentic**: A Python package for building Agentic RAG (Retrieval-Augmented Generation) applications with built-in orchestration capabilities [24].
- **CrewAI**: An open-source framework for creating collaborative AI agents that can work in teams, supporting role specialization and task delegation [31].
- **Autogen**: Microsoft's framework for creating multi-agent conversational systems with customizable agent behaviors.
- **AgentGPT**: Browser-based platform for creating and deploying autonomous AI agents with goal-setting capabilities.
- **Synechron's Agentic Stack**: Proprietary platform combining LLMs with function calling and workflow automation [4].

H) Cloud Services and Deployment Infrastructure

Major cloud provider's offer specialized services for AGI and Agentic AI:

- **AWS Bedrock**: Provides foundation model access and agentic workflow tools through services like Agents for Amazon Bedrock.
- **Microsoft Azure AI Studio**: Offers orchestration tools for multi-agent systems and cognitive services integration.
- **Google Cloud's Vertex AI**: Features custom model training with TPU acceleration and agentic workflow pipelines.
- **NVIDIA AI Foundations**: Cloud service providing access to NVIDIA's generative AI models and agentic tools [18].
- **Specialized Hardware**: Deployment often utilizes NVIDIA H100 and upcoming B100 GPUs, with some research systems employing Cerebras Wafer-Scale Engines or SambaNova reconfigurable dataflow units.

I) Computational Requirements and Hardware

The development of advanced AI systems demands significant computational resources:

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- **Edge Deployment**: Agentic AI systems increasingly leverage edge devices through frameworks like TensorRT-LLM for optimized inference on NVIDIA Jetson platforms.
- **Quantum Hybrid Approaches**: Some research explores quantum-classical hybrid systems for specific AGI components, using platforms like IBM Quantum or Amazon Braket.
- **Energy Efficiency**: New architectures focus on reducing power consumption through techniques like mixture-of-experts (MoE) models and sparsity [40].

J) Benchmarking and Evaluation Tools

Assessing progress toward AGI requires specialized measurement tools:

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- **AGI Safety Benchmarks**: New evaluation suites measure dangerous capabilities and alignment properties [25].
- **Multi-Agent Testing Environments**: Platforms like NetHack and Minecraft serve as rich environments for testing agentic capabilities [19].

K) Summary and Outlook

The technical landscape for AGI and Agentic AI is characterized by rapid innovation across open-source and proprietary frameworks, cloud and hardware infrastructure, and rigorous benchmarking tools. Agentic AI toolkits are bridging the gap between narrow generative models and the broader ambitions of AGI by enabling autonomous, multi-step workflows and seamless tool integration [2, 4, 24]. As both research and industry adoption accelerate, the ecosystem is expected to become increasingly modular, collaborative, and capable of supporting complex, real-world applications.

5. Applications and Implications

A) Business and Industry Impact

The emergence of AGI and Agentic AI is reshaping business strategies across sectors:

- Retail and commerce transformation [29]
- Legal services automation [20]
- Enterprise workflow optimization [41]
- New startup opportunities and business models [42]

Deloitte surveys indicate that 78% of tech leaders see Agentic AI as a key enabler of sustainable value [34], while PwC analysis suggests AI is fundamentally rewriting competitive playbooks [41].

B) Societal Implications
The development of advanced AI systems carries broad societal implications:

- Workforce transformation and job market impacts [43]
- Changes to innovation processes and scientific discovery [44]
- New requirements for education and skills development [45]
- Evolving legal and regulatory frameworks [28]

6. Comparative Analysis of AI Paradigms
A) Taxonomy of Artificial Intelligence
Modern AI systems can be categorized into several distinct paradigms with varying capabilities:

- **Traditional/Narrow AI**: Task-specific systems designed for particular applications (e.g., recommendation engines, computer vision) [12]. These represent the majority of current deployed AI systems.
- **Generative AI (GenAI)**: Systems capable of creating novel content (text, images, code) based on learned patterns [16, 46]. Examples include GPT models and Stable Diffusion.
- **Agentic AI**: Autonomous systems that can plan, make decisions, and execute multi-step workflows [2, 15]. These extend beyond generation to include action-oriented capabilities [17].
- **Artificial General Intelligence (AGI)**: Hypothetical systems with human-level generalization across diverse domains [3, 11]. AGI remains unrealized but is actively researched [6].

B) Capability Comparison
Comparison of AI Paradigms is shown in the table.

Table 1: Comparison of AI Paradigms

Characteristic	Narrow AI	GenAI	Agentic AI	AGI
Task Scope	Single	Multiple	Multiple	Universal
Autonomy	None	Low	High	Complete
Creativity	None	High	Moderate	High
Reasoning	Limited	Pattern-based	Goal-oriented	Human-like
Learning	Static	Continuous	Adaptive	General
Current Status	Deployed	Deployed	Emerging	Research

C) Technical Distinctions
The paradigms differ fundamentally in their architectures and requirements:

- **Data Requirements**: While narrow AI and GenAI typically require large, domain-specific datasets [45], AGI systems aim for efficient learning from diverse data [47]. Agentic AI adds reinforcement learning from environmental feedback [19].
- **Architectural Complexity**: GenAI primarily uses transformer architectures [48], while Agentic AI incorporates planning modules and memory systems [22]. AGI research explores hybrid neuro-symbolic approaches [21].
- **Computational Demands**: GenAI systems require massive inference resources, but Agentic AI adds ongoing computation for decision-making [10]. AGI would theoretically need unprecedented scale [39].

D) Use Case Differentiation
The paradigms excel in different application domains:

- **Narrow AI**: Optimized for specific tasks like fraud detection or predictive maintenance [49].
- **GenAI**: Ideal for content creation, code generation, and data augmentation [16].
- **Agentic AI**: Suited for autonomous customer service, DevOps automation [10], and legal document analysis [20].
- **AGI**: Potential future applications in scientific discovery and complex problem-solving [43].

E) Evolutionary Perspective
The development trajectory shows increasing capability:

1. **First Wave**: Narrow AI systems (2010s) focused on specific tasks [12].
1. **Second Wave**: GenAI (2020s) demonstrated creative generation [46].
2. **Third Wave**: Agentic AI (2024+) introduces autonomous action [4].
3. **Future**: Potential AGI would represent qualitative leap in capability [13].

F) Safety Considerations
Each paradigm presents distinct challenges:

- **Narrow AI**: Bias in training data and overfitting **JonesAGIHypeDamaging2024?**.
- **GenAI**: Misinformation risks and IP concerns [28].
- **Agentic AI**: Unintended consequences of autonomous actions [50].
- **AGI**: Existential risks and alignment problems [38].

This comparative analysis reveals that while these paradigms share technological foundations, they represent fundamentally different approaches to artificial intelligence with distinct capabilities and applications [51, 52]. The AI field continues to evolve rapidly, with Agentic AI emerging as a practical middle ground between today's GenAI and future AGI aspirations [9].

7. Challenges and Limitations
A) Technical Challenges
The path to AGI faces several significant technical hurdles:

- Developing systems with true understanding and reasoning capabilities [53]
- Creating AI that can generalize across diverse domains [49]
- Implementing robust memory and learning mechanisms [47]
- Achieving human-level adaptability and creativity [48]

B) Agentic AI systems face their own set of challenges
- Ensuring reliable autonomous operation [19]
- Maintaining appropriate human oversight [50]
- Managing complex multi-agent interactions [54]
- Balancing autonomy with safety constraints [38]

C) Safety and Ethical Considerations

Both AGI and advanced Agentic AI systems raise important safety concerns

- Potential for misuse or unintended consequences [36]
- Alignment with human values and intentions [40]
- Governance and control mechanisms [39]
- Long-term societal impacts [42]

Recent proposals emphasize the need for urgent safety measures as these technologies advance [38, 55].

8. Conclusion

While AGI remains an ambitious and potentially distant goal [7], Agentic AI represents a practical stepping stone that is already delivering value across industries [9, 56]. The coming years will likely see continued progress in both areas, with several key developments on the horizon:

- Refinement of AGI benchmarks and measurement frameworks [57]
- Expansion of Agentic AI applications across sectors [18]
- Increased focus on safety and governance mechanisms [38]
- Development of hybrid systems combining generative and agentic capabilities [46]

As these technologies evolve, it will be crucial to maintain balanced perspectives that acknowledge both their potential and limitations. Future research should focus on developing robust evaluation methodologies, safety protocols, and practical implementation frameworks to ensure these powerful technologies deliver maximum benefit while minimizing risks.

This comprehensive review has examined the current state of Artificial General Intelligence (AGI) and Agentic AI, analyzing their technical foundations, capabilities, and trajectories. Our investigation reveals several key insights about the evolving AI landscape:

First, while AGI remains an aspirational goal with significant technical hurdles [7, 8], Agentic AI has emerged as a practical intermediate step that is already demonstrating real-world value [9, 10]. The development of frameworks like OpenAI's 5-level AGI classification system [23] and specialized Agentic AI platforms [24] indicates growing sophistication in both domains.

Second, the comparative analysis highlights fundamental differences between AI paradigms. Where traditional narrow AI excels at specific tasks and generative AI at content creation, Agentic AI introduces autonomous decision-making capabilities [2], while AGI promises (but has not yet achieved) human-level generalization [3]. This spectrum of capabilities suggests a maturation path for AI systems, with Agentic AI serving as a crucial bridge between current technologies and future AGI aspirations [51].

Third, the technical requirements for these advanced AI systems are becoming increasingly demanding, from specialized hardware architectures [39] to novel cloud services supporting autonomous agent deployment [18]. These infrastructure developments both enable and constrain progress in the field.

Looking ahead, three critical priorities emerge for researchers and practitioners: Development of Robust Evaluation Frameworks: As Agentic AI systems become more autonomous and AGI research advances, standardized metrics and testing environments [25] will be essential for measuring progress and ensuring reliability. Safety and Governance Mechanisms: The unique risks posed by autonomous systems [50] and potential AGI [38] demand continued investment in alignment research and ethical frameworks.

Practical Implementation Strategies: Organizations should focus on incremental adoption of Agentic AI solutions [34] while maintaining realistic expectations about AGI timelines.

The rapid evolution of these technologies suggests that while AGI may remain years or decades away, Agentic AI is poised for near-term expansion across industries [20, 29]. By maintaining balanced perspectives that acknowledge both the potential and limitations of these paradigms, the AI community can steer development toward beneficial outcomes while mitigating risks.

Future research should particularly focus on hybrid architectures that combine the strengths of different approaches [21], as well as interdisciplinary efforts to address the societal implications of increasingly autonomous AI systems [28, 43]

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