

BEYOND BITS AND QUBITS: THE FUTURE OF GENERATIVE AI IN THE QUANTUM REALM

Quantum Computing &
Gen AI

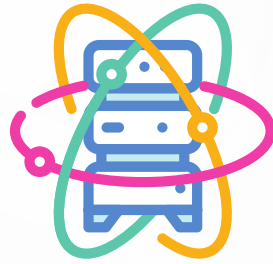
GENERATIVE AI
FOR ALL



What is covered in the document

- In this document we will go through a brief description of Quantum Computing, its basics
- Then we will deep dive Quantum Computing in relation to Generative AI covering:
 - Research and Academic Process
 - Industry Involment
 - Experimental Application
 - Key Collaborations & Initiatives
 - Limitation
 - Notable Development and Milestones
 - Future Prospects

What is Quantum Computing?



“

Quantum computing is an advanced field of computing that uses quantum mechanics principles to perform calculations much faster than classical computers.

”

- Unlike traditional computers that use bits (0 or 1), quantum computers use quantum bits or qubits, which can exist in multiple states simultaneously.

Key Concepts of Quantum Computing



1. Qubits (Quantum Bits)

- Traditional Bits: Can be either 0 or 1.
- Qubits: Can be 0, 1, or both at the same time. This is called superposition.

2. Superposition

- Superposition: Imagine a light switch that is not just on or off, but can be both on and off at the same time. This allows quantum computers to try many different solutions at once.

3. Entanglement

- Entanglement: A magical connection between qubits, where changing one qubit instantly changes another, even if they are far apart. This helps qubits work together in a special way.

Quantum Computing in Gen AI - Research and Academic Progress



- **Quantum Machine Learning (QML):** Active research is being conducted on how quantum computing can enhance machine learning algorithms, including those used for Generative AI.
- **Quantum Algorithms:** Development of quantum algorithms such as the Quantum Approximate Optimization Algorithm (QAOA) and Variational Quantum Eigensolver (VQE) to improve AI performance.
- **Hybrid Approaches:** Research into hybrid models that combine classical and quantum computing to leverage the strengths of both technologies.

Quantum Computing in Gen AI - Industry Involvement

- **Tech Giants:** Companies like IBM, Google, and Microsoft are investing heavily in quantum computing research, including its applications in AI.
- **Startups:** New startups are emerging that focus on developing quantum computing solutions for AI.

Quantum Computing in Gen AI - Experimental Applications

- **Prototype Models:** Quantum computing is being used to develop new types of generative models that can potentially generate more complex data patterns than classical models, by encoding and manipulating data in quantum states.
- **Simulations:** By simulating complex systems with quantum computers, we can optimize AI training processes, leading to faster and more accurate AI models that can learn from less data and handle calculations beyond the scope of classical computers.

Quantum Computing in Gen AI - Collaborations and Initiatives

- **Collaborative Research:** Partnerships between academic institutions, industry leaders, and research labs to advance quantum computing and AI.
- These partnerships are essential for scientific breakthroughs, developing a skilled workforce for the quantum industry, and maintaining a competitive edge in the global economy.
- **Funding and Grants:** Increased funding from government and private sectors to accelerate research in quantum computing and its AI applications.

Quantum Computing in Gen AI - Challenges and Limitations

Technical Challenges

- **Qubit Stability:** Maintaining the stability of qubits during computations (decoherence).
- Qubits are the basic units of quantum information, but they are highly sensitive to their environment. Any interaction with the external world can cause them to lose their quantum properties—a process known as decoherence
- **Error Rates:** High error rates in quantum computations that need to be mitigated.
- **Scalability:** Building scalable quantum computers that can handle large-scale computations required for AI.

Quantum Computing in Gen AI - Challenges and Limitations

Resource Constraints

- **Hardware Availability:** Limited availability of quantum hardware for widespread experimentation.
- Quantum computers are complex machines that require precise conditions to operate, such as extremely low temperatures and isolation from any environmental noise.
- **Cost:** High cost of quantum computing resources, making it difficult for many organizations to access.
- Quantum computers are expensive to build and maintain due to their sophisticated hardware requirements.

Quantum Computing in Gen AI - Notable Developments and Milestones

Quantum Supremacy

- **Google's Achievement:** In 2019, Google announced achieving quantum supremacy, where a quantum computer solved a problem that would be practically impossible for a classical computer.
- Quantum Supremacy term refers to the point at which a quantum computer can perform a calculation that is beyond the practical capabilities of the best classical supercomputers.

Quantum Computing in Gen AI - Notable Developments and Milestones

Quantum AI Research Papers

- **Published Research:** Increasing number of research papers on the integration of quantum computing and AI, exploring theoretical and practical aspects.
- Research is delving into strategic approaches for integrating quantum AI into industry, examining the potential impact on Industry.
- Studies are exploring how quantum computing can benefit from AI advancements across the entire technology stack.

Quantum Computing in Gen AI - Notable Developments and Milestones

Experimental Successes

- **Early Successes:** Some early successes in using quantum computers for small-scale generative tasks, demonstrating potential future applications.
- Research has shown that parameterized quantum circuits (PQCs) can be used as machine learning models with significant expressive power.
- The development of hybrid systems that combine quantum and classical computing elements has made it possible to utilize existing quantum computers to their fullest extent.

Quantum Computing in Gen AI - Future Prospects

Short-Term

- **Enhanced Hybrid Models:** Further development of hybrid models combining classical and quantum computing.
- These models leverage the strengths of both computing paradigms—classical computers' robustness and quantum computers' parallelism and entanglement properties.
- **Algorithm Improvement:** Continued refinement of quantum algorithms for AI applications.
- Quantum machine learning (QML) involves designing algorithms specifically for execution on quantum computers.

Quantum Computing in Gen AI - Future Prospects

Long-Term

- **Scalable Quantum Systems:** Development of more scalable and stable quantum systems that can handle large-scale AI tasks.
- A scalable quantum system is one that can increase its number of qubits while maintaining their stability and coherence, which is essential for performing large-scale computations required for AI tasks.
- **Breakthrough Applications:** Potential for breakthrough applications in generative AI as quantum computing technology matures.

THANK YOU!

Special Thanks to:

Gemini

