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Comparative Analysis of Classical and YOLO Quantum System

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Abstract: Classical computing is a traditional computing system currently used in digital devices like laptops, smartphones, servers and personal computers and works on binary bits concept where information represents in the form of 2 states, either 0 or 1. Classical computing follows deterministic and sequential computing approach leads to efficiently perform normal and daily computational task. On the another hand, quantum computing is an advance and emerging computing paradigm based on the principle of quantum mechanics, in this qubits(quantum bits) are used in place of classical bits and the main thing is qubit exist in both 0 and 1 states simultaneously, also known as superposition. Through quantum computing entanglement and parallel processing, it performs complex calculation comparatively faster than classical system. In this study, comparison between classical and quantum computing is based on multiple parameters like basic unit (bit vs qubit), processing method, speed, determinism, operating condition and application areas. After analyzing, it shows that quantum computing has a lot of potentials for things like cryptography, AI, optimization drug discovery. On the contrary, classical computing is more useful and dependable for everyday computing and general-purpose computing. Study concludes that quantum computing never replaces classical computing instead works as hybrid computing system and supports technical advancement in multiple industries.

Keywords: Classical Computing, Quantum Computing, Qubit, Superposition, Quantum Algorithms, Computational Performance

1.0 Introduction

Evaluation in computing technology take place with respect to time in earlier time it starts with mechanical calculator performs simple mathematical calculations, after that, electronic computer come were developed and with time it become fast, efficient and more accurate. Today’s modern digital system is one of the examples of that. Classical computing is a traditional paradigm used almost in every device like laptops, smartphones, servers and personal computers. It is based on binary digits and follows the deterministic processing. Classical computing normalizes the data storage, communication, automation, and general-purpose computing and establish the foundation of modern technology.

With the advancement in technology, the complexity level of computational problem also raises high. Many limitations and problem come into an image in the domains like Cryptography, molecular simulation, artificial intelligence and optimization [5]. Also, it is difficult to overcome that problem because of sequential

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processing aur binary state restrictions [3]. Quantum computing is introduced to overcome this limitation. Quantum computing is based on quantum mechanics and use qubits to represent multiple state at a time. Superposition and entanglement like concepts make quantum system capable to efficiently process the complex calculations.

Objective of quantum computing is not to replace the classical computing instead, provide better performance in that area where traditional system is limited. This technology used in cryptography, drug delivery, climate modelling, optimization and advanced AI application [4] [11] [15].

The main objective of this paper to compare classical and quantum computing. Discussion includes, fundamental concepts, processing methods, computational performance, application areas and future hybrid computing architecture. Paper scope is limited to conceptual aur analytical comparison and include deep hardware implementation or algorithm coding is not included here [6][7] [10] [14].

2.0 Literature Review

Recently, many researchers are investigating various facets of classical computing versus quantum computing due to rising computational demands and the advancement of quantum technologies. To be more specific, several dimensions of the quantum computing spectrum are being widely investigated. Studies help to make comparisons regarding different type of computational models, processing capabilities, areas of applications, hardware problems and future. The research provides us with various ideas on quantum computing. However, it must be highlighted that a comparative overview of quantum vs classical computing.

According to a more recent paper “Quantum Computing: Vision and Challenges”, by Gill et al (2024–2025), we are in an exciting era of quantum computing revolution, which will change the way we compute information. The paper presents both foundational and application type aspects which are likely to keep quantum computing on the map. It highlights the fundamental computational ideas of superposition and entanglement that can enhance the computational power of classical devices. The study discusses the different uses of Quantum computers like cryptography, logistics, communication, and much more [15].

McArdle et al. (2020) quantum computational chemistry contribution provides greater influence on the chemistry simulation using quantum algorithms. According to the authors, quantum computing can help us solve some molecular and biochemical problems that are still computationally very challenging for classical computers. This research shows an approach for finding quantum algorithms in chemical applications. The paper has turned out to be one of the most cited in the above domain. It indicates the huge potential of quantum technologies in scientific research.

Herman et al. (2023) discusses the involvement of quantum computing in the financial systems. The authors examine quantum computation theory in finance in light of past and possible future developments versus classical methods. The authors investigate the usefulness of QE on financial data classification.

Many more comparative and industry-focus articles enhance our understanding of this relationship. A TechTarget article explains the difference between bits and qubits, classical physics versus quantum mechanics, for example. (2025) There is an article by Quantropi (2021) that addresses a number of security issues and raises concerns regarding how systems can influence encryption and cybersecurity. According to an article on Forbes (by Bernard Marr, 2025), classical computing continues to dominate most computing tasks we encounter in life, but quantum computing is better suited for more specialized tasks [9].

After analysis of the relevant literature, it is concluded that researchers have compared many dimensions of computational systems. Some of the features covered in previous studies bits vs qubit, faster/faster, processor vs processors, classical quantum algorithms (application area), quantum cryptography, the future of classical hardware in can quantum computations, hybrid future of classical/quantum computing. The studies in the

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research area of extrapolation have discussed the issues of exponential scaling, parallel computation and practical implementation problem [14].

Many research gaps still exist, despite the above extensive developments. Most studies or models usually perform analysis, taking selected features into account but lacking an in-depth analysis based, comprehensive multi-dimensional comparison, thus, it is highly essential to evaluate multi-dimensional influential factors. A limited range of studies examines the analysis of operating conditions is including speed, security, etc. Mathematical Formulation is however not used by most of the study. The integration of visual representation and a systematic evaluation of critical challenges has not been used across computing paradigms.

The study detailed goes into great detail about the analysis of classical and quantum computation. The paper also studies the algorithms used in quantum computing. Yet, it does not compare classical and quantum computing on comparative basis. Furthermore, the comparison conducted in Ref. 19 only includes numerical algorithms. Also, the authors of Ref. 19 only compare traditional and quantum computing based on performance. This study thus damages the total comparative study of classical and quantum computing. To conquer such limitations [6][7] [10].

Table 1. Literature Review Summary Table

Author	Year	Focus	Limitation
Gill et al.	2024	Hardware, crypto, scalability	Limited classical
McArdle et al.	2020	Quantum chemistry	Domain-specific only
Herman et al.	2023	Finance applications	No fundamental details
TechTarget	2025	Basic bit vs qubit analysis	Shallow performance
Quantropi	2021	Security threats, encryption	Limited applications
Forbes (Marr)	2025	Daily vs specialized	No mathematical

2.1 Fundamental of Classical and Quantum Computing

Computing technology has become one of the most important foundations of modern society. Every aspect of society today utilizes computing technologies, from the most basic forms of communication to artificial intelligence. Computing technology has undergone massive development over time, allowing computers to perform billions of operations in a short period. Two of the most important developments in computing technology are classical computing and quantum computing. Classical computing is the traditional form of computing that is still used all around the world today. In contrast, quantum computing is a newer form of computing that is utilized to solve complex problems.

Classical computing refers to the conventional model of computing that is used in modern electronic devices. These devices can range from laptops and smartphones to data centers and the servers that

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power the internet. Classical computing uses binary bits to represent information, limiting each bit of data to existing in one of two states: 0 or 1[3].

The working principle of classical computing is based on a deterministic approach. With this approach, the same input and instructions will always yield the same output. The operations in the computer are performed in a specific, sequential order by the computer's processors and memory. The architecture of classical computers is constructed to allow for reliability and stability during its use.

The information in a classical computer can be represented mathematically using binary states.

Equation 1: Binary Representation of Classical Bit:

$$b \in \{0,1\}$$

$$0 \rightarrow \text{OFF/ False/ Low Voltage}$$

$$1 \rightarrow \text{ON/ True/ High Voltage}$$

above equation shows it occupies only one state at a time. Not like Quantum system where no simultaneous state even exists. Diagram to show the simplified architecture of classical computing is given below:

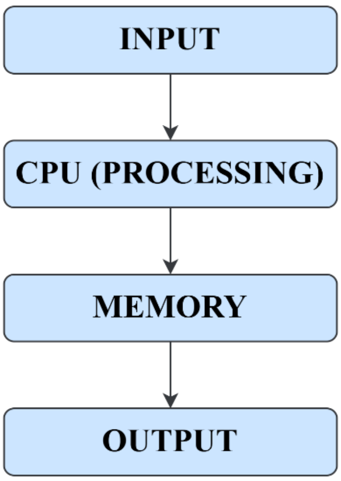

Figure 1: Classical Computing Processing Model

As illustrated in Figure 1, classical systems receive input, process the instructions through the CPU, and either temporarily or permanently store the data within the system's memory, then output the data. These classical system models are used to support the majority of applications that exist in today's systems [2].

Despite the successes of classical computing, complexity in performing certain tasks places limitations upon computing power. Tasks like simulating molecules, performing optimization, performing cryptographic operations, performing climate simulations, and even performing machine learning tasks all require immense computational power to efficiently perform. Search for optimum solution of any problem has most of the time emphasis on minimization.

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Quantum computing is a completely new way of computing that was developed to address these limitations. Quantum computing is based on principles of quantum mechanics and introduces a completely different method of representing and processing information. It uses qubits (quantum bits) over bits.

As compare to classical bit, qubit may exist in several state at a particular time.

Equation 2: Quantum Superposition:

$$|\psi\rangle = \frac{1}{\sqrt{2}}|0\rangle + \frac{1}{\sqrt{2}}|1\rangle$$

Where:

- $|\psi\rangle$ = quantum state
- α = probability amplitude of state 0
- β = probability amplitude of state 1

The above expression indicates the dueling capability of a Qubit for a mixture of both states until a measurement is done.

Table 2: Fundamental Comparison of Classical and Quantum Computing:

Basis	Classical Computing	Quantum Computing
Basic Unit	Bit	Qubit
States	0 or 1	Multiple states
Physics	Classical Physics	Quantum Mechanics
Processing	Sequential	Parallel
Output	Deterministic	Probabilistic
Speed	Moderate	Very high for specific tasks
Temperature	Normal conditions	Controlled environments
Applications	General computing	Complex optimization

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In Table 2, Quantum sciences are sciences that require quantum mechanics to explain the behavior of a specific material / system. These include quantum information, quantum optics and quantum chemistry.

Classical computing will remain dominant in business-related fields such as database systems, software development, business operations and the like. Advanced scientific simulations, artificial intelligence, financial optimization, cryptography, climate modelling, quantum chemistry and logistics are all areas scientists see as important for quantum computing.

Despite these quick advances, quantum computing is not yet in a stage to replace classical infrastructure. Quantum hardware suffers from a multitude of problems such as feed-down and sensitivity to the environment. It is much more scalable and reliable, considerably cheaper and far easier to maintain in classical form.

Detailed Comparison

Table 3.1 Main Comparison Table

Parameter	Classical Computing	Quantum Computing
Data Unit	Bit (0 or 1 only)	Qubit (0, 1, or both simultaneously)
Physics Basis	Classical physics	Quantum mechanics
Processing Method	Sequential (one calculation at a time)	Parallel (2^n states simultaneously)
State Representation	Single state (0 or 1)	Superposition (0 + 1 simultaneously)
Speed	Limited for complex problems	Exponentially fast for specific problems
Storage	Binary (0s and 1s)	Quantum states
Energy Consumption [8]	Higher for large data	Potentially optimized
Reliability	Stable (no random errors)	Error-sensitive (decoherence problem)

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Parameter	Classical Computing	Quantum Computing
Security	Traditional encryption (breakable)	Quantum cryptography (unbreakable) [12]
Scalability[8]	Mature (decades developed)	Developing (50–100 qubits current)
Operating Temperature	Room temperature (~20–25°C)	Extreme cold (-273°C / absolute zero)
Determinism	Deterministic (same input → same output)	Probabilistic (results based on probabilities)
Hardware	CPU, RAM, HDD/SSD, transistors	Quantum processor, cryogenic system, control electronics
Software	Python, C++, Java, traditional algorithms	Qiskit, Cirq, Q#, quantum algorithms [1]
Cost	Affordable (mass production)	Extremely expensive (millions of dollars)
Algorithms	Classical algorithms (Sorting, searching)	Quantum algorithms (Shor's, Grover's) [13]
Computational Complexity	Polynomial for simple tasks, exponential for complex	Exponential parallelism reduces complexity
Best Applications	Daily tasks (browsing, documents, videos, games)	Complex problems (cryptography, drug discovery, AI, optimization) [15]
Error Correction	Easy and well-established	Difficult and challenging

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Parameter	Classical Computing	Quantum Computing
Environment Requirements	Normal room conditions	Vacuum + vibration-free + extreme cold
Current Availability	Everywhere (phones, laptops, servers)	Limited (experimental, research labs)
Technology Maturity	Mature (stable, proven)	Emerging (NISQ era - Noisy Intermediate-Scale Quantum)

Table 3.2 Additional Comparison Points

Table 3.2.1. Hardware Comparison

Aspect	Classical	Quantum
Processor	CPU (Central Processing Unit)	Quantum Processor (QPU)
Memory	RAM (Random Access Memory)	Quantum Memory (qubits)
Storage	HDD/SSD (Hard Disk/Solid State)	Quantum State Storage
Components	Transistors, circuits	Qubits, superconductors, lasers
Size	Compact (laptop/phone size)	Large (room-sized cryogenic system)

Table 3.2.2. Software Comparison

Aspect	Classical	Quantum
Languages	Python, C++, Java, JavaScript	Qiskit (Python), Cirq, Q#[1]
Programming Model	Deterministic	Probabilistic

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Libraries	NumPy, Pandas, TensorFlow	Qiskit, Pennylane, Cirq[1]
Debugging	Easy, standard tools	Difficult, specialized tools

Table 3.2.3. Cost Comparison

Aspect	Classical	Quantum
Hardware Cost	\$300–\$3000 (laptop/phone)	\$10 million–\$150 million
Maintenance Cost	Low	Extremely high
Cooling Cost	Normal (room temperature)	Extreme (cryogenic system)
Accessibility	Everyone can access	Research labs only

Table 3.2.4. Algorithms Comparison

Aspect	Classical	Quantum
Algorithm Type	Deterministic	Probabilistic
Examples	Sorting, searching, regression	Shor's, Grover's, QAOA [13]
Complexity	$O(n)$, $O(n^2)$, $O(\log n)$	$O(\sqrt{n})$, $O(\log n)$ for some problems
Speed Advantage	Standard	Exponential for specific problems

Table 3.2.5. Complexity Comparison

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Problem Type	Classical Complexity	Quantum Complexity
Factorization	$O(e^n)$ - exponential	$O(n^3)$ - polynomial (Shor's) [13]
Search	O(n) - linear	$O(\sqrt{n})$ - square root (Grover's)
Simulation	$O(e^n)$ - exponential	O(n) - polynomial
Optimization	$O(n^2)$–$O(e^n)$	O(n)–O(log n)

3.0 Real World Use Case

Classical computing has had the benefit of decades of optimization and is inexpensive and stable. Almost 100 percent of all things computers do today — whether surfing the web; cloud computing; mobile apps; gaming; databases; Microsoft Office; email; Netflix — is done via classical computing. Explaining the real-world difference between classical and quantum computing, and where each technology performs best, the statement notes three tasks classical systems are best suited for. First, they are exceptionally adept at routine tasks that require reliable, structured processing [5]. Quantum computing focuses on solving complicated problems using the quantum principles of superposition, in which something appears in all possible states at the same time, until you measure it, and of processing that happens in parallel . As a result, quantum systems are expected to significantly reduce the computation time required for certain, specialized problems. They've already demonstrated potential in solving a variety of challenges, from quantum chemistry, drug discovery and cryptography to optimization problems and weather prediction to streamlining logistics, modeling financial data and enhancing artificial intelligence .

Many organizations have already tested both technologies in real life. Companies providing search engines, cloud platforms, operating systems and digital services continue to be driven by legacy infrastructure. Moreover, quantum research is a boon for simulation and optimization. Although it's still a work in progress, quantum computing is advanced. In addition, the prices are not affordable due to the fact that they still undergo upgrading. Over the years, many people felt that quantum computing will dominate classical computing entirely. But the truth is the opposite. A comprehensive analysis that outlines the differences between quantum and classical computing is provided below. This will show clearly how both computing can work together.

4.0 Conclusion

A comparison has been made between classical computing and quantum computing and is done so in terms of basic units, physics, processing, speed, operating conditions and applications of both the computing types. Classical computers use bits to encode information, quantum computers on the other hand use qubits. Classical physics is employed by classical computing but quantum computing uses

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quantum mechanics. While quantum computing employs parallel processing, classical computing utilizes sequential processing. Classical computers are slower yet quantum computers are quicker. Classical computing Temperature is normal quantum computing temperature is near absolute zero temperature. If you possess N qubits, you are able to process 2N values in parallel owing to their superposition, the research says. Consequently, quantum computing operates much faster than classic computing, which only employs N values. A few applications of quantum computing include cryptography, drug discovery, AI, optimization, and scientific simulation . Computers are great for browsing the web, using apps on your mobile, playing games and word processing.

Future Scope

Future computing is likely to collocate hybrid computing whence classical and quantum computers work over the same system and not replace each other. In the near future, quantum computers will solve complex problems and classical computers will handle day-to-day [14].

This development is being worked on by companies. Users will be able to access a quantum computer over the cloud thanks to this without purchasing the hardware themselves.

Quantum technologies are forecast to be used by many different industries for solving optimization problems, such as financial organizations, pharmaceuticals, logistics, and energy, including developing better drugs, planning more efficient routes, and optimizing batteries[15].

And as quantum hardware improves in coming years, with higher computational power, lower costs and more qubits, these technologies should see wider adoption. Future technologies will also include quantum internet, quantum cryptography and faster training of AI. Most secure computational systems would be aided by these technologies.

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