Week 6 Assignment

Part 1: *Theoretical Analysis*

Q1: *Explain how **Edge AI** reduces latency and enhances privacy compared to cloud-based AI. Provide a real-world example (e.g., autonomous drones).*

The growth of connected devices (IoT) has historically relied on centralised cloud computing to run AI. However, this architecture is increasingly constrained by network latency and data privacy risks. Edge AI—processing data directly on or near the source—offers a fundamental architectural shift that resolves these challenges, delivering ultra-low latency and significantly enhancing data security compared to cloud-based predecessors.

The most critical advantage of Edge AI is its ability to enable rapid decision-making. Traditional Cloud AI introduces significant backhaul latency as data must travel across the network to a distant data center, be processed, and have the decision returned. Edge AI eliminates this network delay by performing AI inference right where the data is created. This immediate, on-device processing converts response times from seconds to milliseconds, enabling true real-time decision-making.

Edge AI significantly enhances privacy by ensuring raw, sensitive data remains local. Cloud AI requires transferring sensitive data, such as live video feeds or biometric information, over public networks to a third-party server, creating multiple security vulnerabilities. Edge processing ensures that only processed, aggregated, or anonymized insights are ever transmitted, simplifying compliance with stringent regulations like GDPR and HIPAA.

A powerful real-world example is the **autonomous inspection drone**. A cloud-based drone would stream video to a remote server for obstacle detection and path planning. If network connectivity is weak, the resultant backhaul latency can delay obstacle recognition by a fatal margin, leading to mission failure or a crash. Conversely, an Edge AI-powered drone utilizes an onboard Neural Processing Unit (NPU) to perform computer vision and collision avoidance instantly. This sub-millisecond response is independent of the network. For surveillance, the drone processes the feed locally, only flagging and transmitting an image *if* a specific anomaly is detected, ensuring confidential visual data remains securely on the device.

In conclusion, while Cloud AI remains vital for large-scale training and analytics, Edge AI is the future of real-time operational intelligence. By minimizing data round-trips and network exposure,

this pivot enables a new generation of truly autonomous, reliable, and secure systems across all industries.

Q2: *Compare **Quantum AI** and classical AI in solving optimisation problems. What industries could benefit most from Quantum AI?*

Modern computing demands instant, secure, on-site processing and the power to solve previously intractable problems. **Edge AI** and **Quantum AI** address these, fundamentally redefining architectural design across all industries.

Edge AI specifically focuses on delivering **speed and security at the source**. Centralised cloud computing is severely constrained by **network latency** due to distant data round-trips, but Edge AI resolves this by embedding inference directly at the source, achieving millisecond-level, real-time decision-making for autonomous applications. Crucially, Edge AI also boosts **data privacy**. Since Edge processing keeps raw, confidential data local and only transmits anonymised insights, it minimises exposure and simplifies compliance (e.g., GDPR, HIPAA).

The **autonomous inspection drone** is a compelling example of this paradigm. While Cloud AI-reliant drones risk fatal delays from network failure, Edge AI uses an onboard NPU for instant collision avoidance. This local processing guarantees safety, is independent of connectivity, and ensures confidential visual data remains on-device.

Moving **beyond Edge** to tackle computational limits, **Quantum AI (QAI)** addresses optimisation problems intractable for classical systems. The fundamental difference lies in their processing unit: Classical AI uses binary **bits** and sequential search, while QAI employs **qubits**, **superposition**, and **entanglement** to achieve "quantum parallelism," exploring exponentially vast solution spaces simultaneously for massive speedups in complex combinatorial problems.

QAI's ability to find optimal combinations from complex data will revolutionise several high-stakes industries: It will transform **Finance** (hyper-optimised portfolio allocation/risk modelling), accelerate **Drug Discovery** and materials science (quantum-level molecular simulation), and optimise **Logistics** (solving "Travelling Salesman Problem" variants for fleet scheduling).

In conclusion, the future of AI hinges on these complementary strengths: Edge AI provides ubiquitous, real-time autonomy, while Quantum AI expands computational boundaries. Together, they enable a new generation of faster, more secure systems capable of solving previously impossible problems.