Interference Quantum Classifier (IQC)

Patent Claims Specification (Method, System, and Use Claims)

Technical Field

The present invention relates to quantum information processing and machine learning, and more particularly to quantum classification systems that utilize quantum interference for decision-making while performing learning outside quantum circuits.

Background and Problem Addressed

Existing quantum machine learning classifiers typically rely on:

- variational quantum circuits with trainable gate parameters,
- fidelity or probability-based measurements that are quadratic in quantum amplitudes,
- repeated circuit executions with shot complexity scaling with dataset size.

These approaches suffer from instability, loss of phase information, and impractical execution costs on near-term quantum hardware.

The present invention addresses these limitations by introducing a quantum classification framework based on **linear quantum interference**, wherein learning is performed classically on quantum state representations, and inference is executed by a fixed quantum interference circuit.

Summary of the Invention

The invention provides:

- a quantum classification method based on the sign of a linear interference observable;
- a separation between learning dynamics and quantum circuit execution;
- quantum memory states that represent class information;
- constant-measurement inference independent of dataset size.

CLAIMS

Claim 1 — Independent Method Claim (Core Invention)

A computer-implemented method for quantum classification, comprising:

1. receiving an input sample represented as a feature vector;
2. encoding the feature vector as a quantum state $|\psi\rangle$ in a Hilbert space;
3. maintaining at least one quantum class state $|\chi\rangle$ representing a class;
4. executing a quantum interference circuit configured to produce a measurement outcome proportional to a real-valued linear inner product $\mathrm{Re}\langle\chi|\psi\rangle$;
5. assigning a class label to the input sample based on the sign of the measurement outcome;

wherein the classification decision is derived from linear quantum interference rather than a quadratic probability or fidelity measurement.

Claim 2 — Fixed Quantum Circuit

The method of Claim 1, wherein the quantum interference circuit is fixed, non-parameterized, and independent of any learning process.

Claim 3 — Separation of Learning and Inference

The method of Claim 1, wherein no learning, optimization, or parameter update occurs within the quantum interference circuit.

Claim 4 — Learned Object Is a Quantum State

The method of Claim 1, wherein learning consists solely of updating the quantum class state $|\chi\rangle$, and no quantum gate parameters are trained.

Claim 5 — Online Quantum State Update Rule

The method of Claim 4, wherein the quantum class state is updated according to:

$$|\chi_{t+1}\rangle = (|\chi_t\rangle + \eta\cdot y\cdot|\psi\rangle) / \| |\chi_t\rangle + \eta\cdot y\cdot|\psi\rangle \|,$$

where y is a class label and η is a learning rate.

Claim 6 — Incremental and Few-Shot Learning

The method of Claim 5, wherein the quantum class state is updated incrementally upon receipt of new labeled samples without retraining previously processed samples.

Claim 7 — Phase-Sensitive Classification

The method of Claim 1, wherein the quantum interference circuit preserves relative phase information between the quantum class state $|\chi\rangle$ and the input state $|\psi\rangle$.

Claim 8 — Constant Measurement Complexity

The method of Claim 1, wherein the quantum interference circuit requires a constant number of measurements independent of dataset size.

Claim 9 — Multi-State Quantum Memory

The method of Claim 1, further comprising maintaining a plurality of quantum class states $\{ |\chi^{(j)}\rangle \}$, and determining a class label based on a maximum linear interference score across the plurality.

Claim 10 — Absence of Fidelity Estimation

The method of Claim 1, wherein classification is performed without estimating quantum state fidelity, squared probability amplitudes, or kernel matrices.

Claim 11 — Independent System Claim

A quantum classification system comprising:

1. a classical feature extraction module configured to generate normalized embeddings;
2. a memory component storing one or more quantum class states;
3. a quantum processor configured to execute a quantum interference circuit that evaluates $\mathrm{Re}\langle\chi|\psi\rangle$;
4. a classical decision module configured to assign class labels based on the sign of the evaluated interference value.

Claim 12 — Hardware-Agnostic Execution

The system of Claim 11, wherein the quantum interference circuit is executable on a simulator, a near-term quantum processor, or a fault-tolerant quantum processor without modification of the learning procedure.

Claim 13 — Read-Only Quantum Inference

The system of Claim 11, wherein the quantum processor performs inference without modifying stored quantum class states.

Advantages of the Invention

• Linear interference preserves sign and phase information lost in fidelity-based classifiers.
• Learning is stable and deterministic due to classical update rules.
• Quantum circuit depth and measurement cost are minimized.
• The invention is compatible with near-term quantum hardware.

Scope and Interpretation

The claims are intended to cover all implementations that:

• use linear quantum interference as the decision primitive;
• separate learning from quantum inference;
• represent learned class information as quantum states.

Variations in encoding schemes, feature extractors, and physical circuit realizations are considered within the scope of the claims, provided the core interference-based decision mechanism is preserved.