Qeios

Peer Review

Review of: "A Review of Formal Methods in Quantum Circuit Verification"

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This article does not justify why the reader should consider barrier certificates or abstract interpretation for verifying quantum circuits, or what makes them stand out from other verification methods.

Barrier certificates originate in the safety verification of dynamical systems; the article doesn't explain what structure of quantum circuits makes barrier certificates particularly natural beyond saying they were "adapted". Many verification papers might directly or indirectly use barrier certificates, and the article's discussion provides little guidance on how to design verification methods for quantum circuits. It would be better if the article explained what is quantum-specific about the approach.

The article also does not explain what abstract interpretation is, merely describing it as "analysing system behaviour using sound semantic approximations". Based on this explanation, it is also too broad to guide the design of quantum circuit verification methods.

The section "5.2. Theorem Proving" might be even more useful because it at least lists the proof assistants/languages the previous works used. This is a good starting point for a potential revision. In a revision, the authors could state what verification problem class each method targets, discuss why each method is particularly suitable for each problem class, and give a one-paragraph "when to use what" map.

The following are detailed comments on each section.

2. Background

The quantum part needs more work. Even multi-qubit states aren't defined.

> Unlike testing, which checks only some behaviours, formal methods consider all possible behaviours.

What do you mean by "all possible behaviours"? In my opinion, formal methods establish correctness *relative to* a specification. They do not address behaviours outside the specification/model assumptions.

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3. Barrier Certificates

> 3.2. Scenario-based Approach

> 3.3. Scenario-Based Approach

Please do not write the same section twice.

4. Abstract Interpretation

> assolini2025formal [35] propose a semantic framework based on abstract interpretation for verifying VQCs.

Please cite the paper by the authors' names (e.g., "Assolini et al.") rather than a BibTeX key.

5. Other Formal Methods

> The authors of [71][72] have developed deductive approaches to quantum circuit verification using SMT solvers.

Please include the paper titles in the text, not only bracketed numbers.

Declarations

Potential competing interests: No potential competing interests to declare.