physics:boson gate

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1 Super controlled gates and controlled gates in two-qubit gate simulations

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Metadata

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quant-ph :: 4 pages, no figures

Summary

In two-qubit gate simulations an entangling gate is used several times together with single qubit gates to simulate another two-qubit gate. We show how a two-qubit gate's simulation power is related to the simulation power of its mirror gate. And we show that an arbitrary two-qubit gate can be simulated by three applications of a super controlled gate together with single qubit gates. We also give the gates set that can be simulated by n applications of a controlled gate in a constructive way. In addition we give some gates which can be used four times to simulate an arbitrary two-qubit gate.

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2 Impact of Gate Assignment on Gate-Holding Departure Control Strategies

Sang Hyun Kim, Eric Feron

Metadata

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Summary

Gate holding reduces congestion by reducing the number of aircraft present on the airport surface at any time, while not starving the runway. Because some departing flights are held at gates, there is a possibility that arriving flights cannot access the gates and have to wait until the gates are cleared. This is called a gate conflict. Robust gate assignment is an assignment that minimizes gate conflicts by assigning gates to aircraft to maximize the time gap between two consecutive flights at the same gate; it makes gate assignment robust, but passengers may walk longer to transfer flights. In order to simulate the airport departure process, a queuing model is introduced. The model is calibrated and validated with actual data from New York La Guardia Airport (LGA) and a U.S. hub airport. Then, the model simulates the airport departure process with the current gate assignment and a robust gate assignment to assess the impact of gate assignment on gate-holding departure control. The results show that the robust gate assignment reduces the number of gate conflicts caused by gate holding compared to the current gate assignment. Therefore, robust gate assignment can be combined with gate-holding departure control to improve operations at congested airports with limited gate resources.

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3 Achieving short high-quality gate-all-around structures for horizontal nanowire field-effect transistors

J. G. Gluschke, J. Seidl, A. M. Burke, R. W. Lyttleton, D. J. Carrad, A. R. Ullah, S. Fahlvik Svensson, S. Lehmann, H. Linke, A. P. Micolich

Metadata

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physics.app-ph :: Submitted to Nanotechnology

Summary

We introduce a fabrication method for gate-all-around nanowire field-effect transistors. Single nanowires were aligned perpendicular to underlying bottom gates using a resist-trench alignment technique. Top gates were then defined aligned to the bottom gates to form gate-all-around structures. This approach overcomes significant limitations in minimal obtainable gate length and gate-length control in previous horizontal wrap-gated nanowire transistors that arise because the gate is defined by wet etching. In the method presented here gate-length control is limited by the resolution of the electron-beam-lithography process. We demonstrate the versatility of our approach by fabricating a device with an independent bottom gate, top gate, and gate-all-around structure as well as a device with three independent gate-all-around structures with 300 nm, 200 nm, and 150 nm gate length. Our method enables us to achieve sub-threshold swings as low as 38 mV/dec at 77 K for a 150 nm gate length.

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4 Pulse-engineered Controlled-V gate and its applications on superconducting quantum device

Takahiko Satoh, Shun Oomura, Michihiko Sugawara, Naoki Yamamoto

Metadata

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quant-ph :: 9 pages, 14 figures

Summary

In this paper, we demonstrate that, by employing OpenPulse design kit for IBM superconducting quantum devices, the controlled-V gate (CV gate) can be implemented in about half the gate time to the controlled-X (CX or CNOT gate) and consequently 65.5% reduced gate time compared to the CX-based implementation of CV. Then, based on the theory of Cartan decomposition, we characterize the set of all two-qubit gates implemented with only two or three CV gates; using pulse-engineered CV gates enables us to implement these gates with shorter gate time and possibly better gate fidelity than the CX-based one, as actually demonstrated in two examples. Moreover, we showcase the improvement of linearly-coupled three-qubit Toffoli gate, by implementing it with the pulse-engineered CV gate, both in gate time and the averaged output-state fidelity. These results imply the importance of our CV gate implementation technique, which, as an additional option for the basis gate set design, may shorten the overall computation time and consequently improve the precision of several quantum algorithms executed on a real device.

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5 Time-optimal multi-qubit gates: Complexity, efficient heuristic and gate-time bounds

Pascal Baßler, Markus Heinrich, Martin Kliesch

Metadata

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quant-ph :: 11+2 pages, 2 figures

Summary

Multi-qubit interactions are omnipresent in quantum computing hardware, and they can generate multi-qubit entangling gates. Such gates promise advantages over traditional two-qubit gates. In this work, we focus on the quantum gate synthesis with multi-qubit Ising-type interactions and single-qubit gates. These interactions can generate global ZZ-gates (GZZ gates). We show that the synthesis of time-optimal multi-qubit gates is NP-hard. However, under certain assumptions we provide explicit constructions of time-optimal multi-qubit gates allowing for efficient synthesis. These constructed multi-qubit gates have a constant gate time and can be implemented with linear single-qubit gate layers. Moreover, a heuristic algorithm with polynomial runtime for synthesizing fast multi-qubit gates is provided. Finally, we prove lower and upper bounds on the optimal GZZ gate-time. Furthermore, we conjecture that any GZZ gate can be executed in a time O(n) for n qubits. We support this claim with theoretical and numerical results.

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6 Statistical distribution of the reversible gates: what percentage of them are self-inverse?

Anirban Pathak

Metadata

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quant-ph :: 8 pages, no figure

Summary

It is well known that most of the frequently used reversible logic gates (e.g., NOT, CNOT, SWAP, Toffoli, Fredkin) are self-inverse and are represented by square matrices that are unitary and Hermitian. However, with a simple minded argument, it is established that the most of the allowed reversible gates are non-self-inverse (unitary but non-Hermitian) in nature. It is also shown that the example, 58.334-bit gates are non-Hermitian. As classical reversible gates are essentially permutation gates, above statistics is strictly valid for classical reversible gates, but the argument can be easily extended to include quantum gates and to establish that the majority of the quantum gates are also non-self-inverse. Further, the cannot be decomposed as a product of two single bit gates) among all possible gates has been computed as 83.3optimization of circuit cost is discussed.

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7 Decomposition of orthogonal matrix and synthesis of two-qubit and three-qubit orthogonal gates

Hai-Rui Wei, Yao-Min Di

Metadata

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quant-ph :: 7 pages,5 figures

Summary

The decomposition of matrices associated to two-qubit and three-qubit orthogonal gates is studied, and based on the decomposition the synthesis of these gates is investigated. The optimal synthesis of general two-qubit orthogonal gate is obtained. For two-qubit unimodular orthogonal gate, it requires at most 2 CNOT gates and 6 one-qubit Ry gates. For the general three-qubit unimodular orthogonal gate, it can be synthesized by 16 CNOT gates and 36 one-qubit Ry and Rz gates in the worst case.

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8 General structures of reversible and quantum gates

Kishore Thapliyal, Anirban Pathak

Metadata

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quant-ph :: 14 pages, 1 figure

Summary

The most general structure (in matrix form) of a single-qubit gate is presented. Subsequently, used that to obtain a set of conditions for testing (a) whether a given 2-qubit gate is genuinely a 2-qubit gate, i.e., not decomposable into two single qubit gates and (b) whether a given single qubit gate is self-inverse? Relevance of the results reported here is discussed in the context of optimization of reversible and quantum circuits, especially for the optimization of quantum cost. A systematic procedure is developed for the identification of the non-decomposable 2-qubit gates. Such a non-decomposable 2-qubit gate along with all possible single qubit gates form a universal quantum gate library. Further, some possible applications of the present work are also discussed.

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9 On Binomial Summations and a Generalised Quantum SWAP Gate

Colin Wilmott, Peter Wild

Metadata

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quant-ph :: 22 pages, 6 figures

Summary

We give a quantum gate construction - composed entirely from incidents of the CNOT gate - that generalises the qubit SWAP gate to higher dimensions. This new construction is more regular than and is an improvement on the WilNOT quantum gate construction.

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10 Optimal simulation of three-qubit gates

Nengkun Yu, Mingsheng Ying

Metadata

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Summary

In this paper, we study the optimal simulation of three-qubit unitary by using two-qubit gates. First, we give a lower bound on the two-qubit gates cost of simulating a multi-qubit gate. Secondly, we completely characterize the two-qubit gate cost of simulating a three-qubit controlled controlled gate by generalizing our result on the cost of Toffoli gate. The function of controlled controlled gate is simply a three-qubit controlled unitary gate and can be intuitively explained as follows: the gate will output the states of the two control qubit directly, and apply the given one-qubit unitary u on the target qubit only if both the states of the control are $|1\rangle$. Previously, it is only known that five two-qubit gates is sufficient for implementing such a gate [Sleator and Weinfurter, Phys. Rev. Lett. 74, 4087 (1995)]. Our result shows that if the determinant of u is 1, four two-qubit gates is achievable optimal. Otherwise, five is optimal. Thirdly, we show that five two-qubit gates are necessary and sufficient for implementing the Fredkin gate(the controlled swap gate), which settles the open problem introduced in [Smolin and DiVincenzo, Phys. Rev. A, 53, 2855 (1996)]. The Fredkin gate is one of the most important quantum logic gates because it is universal alone for classical reversible computation, and thus with little help, universal for quantum computation. Before our work, a five two-qubit gates decomposition of the Fredkin gate was already known, and numerical evidence of showing five is optimal is found.