TEMA Tendências em Matemática Aplicada e Computacional
Official answer for the obtained reports
Quantum Processes: A Novel Optimization for Quantum Simulation
Authors: A. Maron, R. H. S. Reiser, M. Pilla and A. Yamin

Dear Editors,

The authors accepted the main suggestion's reviewers and based on that the paper was carefully checked. The reviewer's comment's and corresponding author's answers are listed in the tables below. They also would like to thank you and the reviewers for the well done suggestions in the improvement of this paper.

Best regards,

A.Maron, R.H. S. Reiser, M.Pilla and A. Yamin.

- **REVIEWER B**

General Comments: The author(s) study(ies) optimizations to the simulation of quantum algorithms by classical computers. The adopted approach is different than most quantum simulators. Quantum gates are represented by "Quantum Processes" and "Partial Quantum Processes", which are concepts introduced in the qGM theoretical model. I am concerned with some statements.

N	Description (Reviewer B) Minor comments on the writing	Revisions
7.	Pages 1 and 2, abbreviation "e.i." Did you mean "e.g." (exempli gratia, for example) or "i.e." (id est, that is) ?	We corrected this denotation mistake.
8.	- page 1: "behaviors" -¿ "behaviours" Page 1: you don't need to enclose citation in parenthesis, so you may write [8] instead of ([8]).	"behaviors" was kept since it is the correct US English spell. The enclosed citation was corrected.
9.	Page 2, second paragraph: Improve punctuation! For example: "This article is structured as follows. In Section 2, we present the basic background (...). In Section 3, we present the theory and implementation (...) " - page 2, second equation (unnumbered), r.h.s., should be $\alpha - \beta$ instead of "$\beta - \beta$"	We corrected these mistakes.
10.	By the way, equations should always be numbered - pages 2, 3, etc: "Pauly" -¿ "Pauli"	We revised the equations presented in the paper and numbered all them.
11.	Page 3: "as described in (2.1)" -¿ "as described in the following example:"	We accepted the suggestion's author.
12.	Page 9, last paragraph: "both approache" -¿ "both approaches" - page 10, first paragraph, "python" -¿ "Python"	We corrected this spelling mistake.
13.	Run a spell checker!	The text was carefully revised.

N	Description (Reviewer B) Other comments	Revisions
2.	- page 1: Grover's algorithm [1] is being cited as an algorithm exponentially faster than its classical version! It was certainly an important breakthrough in quantum computing, but it is not exponentially faster!	The authors revised and rewrote the Introduction.
3.	page 3: "simulations based on matrix notation are unfeasible". I understand that, in some simulations, memory consumption using the qGM model was significantly better than memory consumption using the naive approach. However, if I understood correctly, even the qGM model could not avoid the exponential scaling of memory consumption – if not for the storage of quantum gates, at least for the storage of the state vector of the algorithm being simulated. So, what is the criteria used by the author(s) to consider simulations based on matrix notation "unfeasible", and their own method "feasible"?	We agree with the comment's reviewer. So, we reorganized this paragraph emphasizing the relevance of this paper proposed optimizations in order to provide a more efficient representation of multi-qubit quantum transformations in the VPE-qGM.
4.	page 11: "even after the optimizations described in this work, the best simulators available still outperforms the VPE-qGM". Since the focus of the paper should be "optimization for reduction of temporal and spatial complexities", it is kind of frustrating that the proposed simulator is not better than other simulators available (although it is better than previous versions of itself). If there are aspects (or maybe specific simulation set-ups) in which VPE-qGM is better than other simulators, the author(s) should make it clear.	The authors present a better explanation of the main contribution of VPE-qGM for the quantum simulation area. Case studies considering the Grover's Algorithm are explored to show how the VPE-qGM can obtain a good performance. Furthermore, a more detailed discussion on how the environment can improve the simulation after future work is presented.
5.	In Section 4, "Performance Analysis of the Optimizations", two case studies were considered. The first, considers benchmarks available in [14], which are benchmarks used for classical reversible circuits. The second, considers only Hadamard gates. In both cases, there is no entanglement generation during the execution of the algorithm. I wonder if the case studies could be better chosen in order to represent greater challenges in terms of quantum computer simulation.	As requested by the reviewers, the authors introduced the Grover's Algorithm Simulation, in Section 4.2. Additionally, the simulations of such algorithm were detailed described based on demanding of execution time and memory space and the perspectives of these improvements were projected in the execution based on GPUs multiprocessor architecture, in Section 4.3.
6.	The original contributions are not clear in the paper. What is clear from the text, is that improvements were achieved when comparing to previous versions of the same VPE-qGM simulator. However, this is not enough to justify the publication of the paper. I am not convinced that the proposed method achieves significant improvements when compared to other methods from literature. Therefore, I cannot recommend publication of the manuscript in its current form.	We describe how the concepts of QPs and QPPs are explored in the VPE-qGM environment in order to improve its simulation capabilities, specially in the realm of controlled transformations. A detailed analysis of the simulation is provided, together with the upsides and downsides of our solution.

- **REVIEWER C**

General Comments: This is a very well written paper with interesting results on simulation of quantum process and have merits to be accepted to publication in the TEMA.

N	Descriptions (Reviewer C) Suggestions of small modifications	Revisions
1	The reference [3] must be actualized: A Juan C. Agudelo, Walter Alexandre Carnielli: Paraconsistent Machines and their Relation to Quantum Computing. J. Log. Comput. 20(2): 573-595 (2010).	We accepted these suggestions and applied them in some paragraphs in the article.
2	In general the bibliography need be actualized with more recent publications prioritizing the publications in journals (the paper just cite one journal paper and it is of 1997).	We reorganized the introduction, see it in the third paragraph, in page 2. Additionally we introduced some examples of main properties of IFSs.
3	Acronyms in the references such as qgm and Phd must be write with the adequate upper and lowercase.	We revised and corrected these mistakes.

- **REVIEWER D**

General Comments: The paper presents optimizations by the description of quantum transformations using quantum processes and partial quantum processes, conceived in the qGM theoretical model. The performance evaluation of this proposal was carried out by benchmarks used in similar works and included the sequencial simulation of quantum algorithms up to 24 qubits. The results obtained are quite interesting and promising. The text is well written and well structured. Figures and equations are clear and significant.

N	Descriptions (Reviewer C) Suggestions of small modifications	Revisions
1	Reference [13] is incomplete (no authors?).	We corrected this reference.