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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Mile Mitrovic

PhD Program: Engineering Systems

Title of Thesis: Data-driven stochastic AC-OPF using Gaussian processes

Supervisor: Assistant Professor Elena Gryazina
Co-supervisor: Assistant Professor Petr Vorobev

Name of the Reviewer: ASHOK KUMAR PRADHAN

I confirm the absence of any conflict of interest	**Date: 07-10-2023**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

Report for the Doctoral Thesis - Data-Driven Stochastic AC-OPF using Gaussian Processes

by Mile Mitrovic, Skolkovo Institute of Science and Technology

General Observations

Today, with the increasing penetration of renewable energy, transmission system operators are observing fast and large fluctuations in power and voltage profiles in the grid. Precise and fast control actions are critical to ensuring power system security and economics. In this respect, optimal power flow (OPF) with numerous operational constraints is a challenging optimization problem for the secure and economic operation of the power grid. This thesis formulates the OPF challenge as a chance-constrained (CC) OPF problem, and using a data-driven approach provides the solution therefor, which ensures a balance between computational complexity and solution accuracy.

The CC-OPF approach aims to minimize power generation costs while providing optimal power dispatch even with the dynamic operational parameters and demand variations in a power grid. The CC-OPF satisfies the operational constraints, which are ensured with a high probability even with sudden changes in RES generation. This is achieved by using a Gaussian process (GP) regression model in place of the standard AC power flow (PF) equation and the security constraints.

Two solution methods are proposed (i) Gaussian process CC-OPF replacing the AC-power flow balance equations and (ii) hybrid GP CC-OPF, which combines linear direct current (DC) PF balance equations with the data-driven estimation of the residuals between DC-PF and AC-power flow based on GPR. The two approaches differ in terms of the training methodologies applied.

The proposed methods are validated using standard IEEE test cases and compared with state-of-the-art approaches. The results clearly demonstrate the strength of the propositions.

Besides accuracy and speed, the methods have the advantage of not requiring knowledge of the grid configuration and parameters. To the author's credit, the software designed and developed to implement the approaches is documented and a user guide is prepared.

The thesis is well written. The figures and tables are presented and elucidated very well. The title is precise as to the work carried out. The mathematical formulations and proposed solutions are all correct. The thesis work is timely and is of high relevance to the power system community for economic and secured operations. The outcome of the work will be of beneficial to electric power systems and society as a whole.

There are very good publications out of the thesis. Importantly, the software developed out of the work on power systems for possible usage is praiseworthy. I congratulate the author for his excellent work on optimal power flow for transmission system operation.

Remarks

Following points may help in improving the thesis.

Page 17, last paragraph- here issues in today's power systems related to renewables integration are mentioned. It may be good to add issues related to inertia, frequency and voltage of the system.

Page 18, paragrapgh-1, [Ullah 2022], here it would be better to state on- 'What is chance-constrained (CC)?

can not should be single word.

Paragraph-2, line2, what is Alternating Current here? You may provide a statement here.

Page 25, last line, low should be law.

Page 27, equation (2.6) . We know S=VI*. Is the equation ok?

Page 41, last line, does it mean the load power factor is fixed?

Page 42, last statement, perhaps it outlies also- active and reactive powers at renewables, load and other form of generations.

Page 51, 3.3.2, line-3, training data (not tada).

Page 73, In Chapter-5 number of training cases are mentioned. It would be better to include that here also.

Page 79, Fig 4.5 is for IEEE bus and Fig 4.6 is for 39 bus. In both the results, frequency is scaled to around 200. What does it imply? What are the number of simulation cases for different systems?

Page 81, What is the general guideline for training data preparation? What coverage it should have in the operating space of a power system?

Provisional Recommendation
Y☑ ***I recommend that the candidate should defend the thesis by means of a formal thesis defense***
☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*
☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*