Qeios

Peer Review

Review of: "Annealed Stein Variational Gradient Descent for Improved Uncertainty Estimation in Full-Waveform Inversion"

Ban Sok Shin[1]

1. Institute of Communications and Navigation, German Aerospace Center (DLR), Köln, Germany

The paper describes findings from applying the annealed Stein variational gradient descent (A-SVGD) to the imaging problem of variational inference-based FWI. In addition, PCA and a clustering method are included to interpret and analyse the resulting particles from A-SVGD FWI. Applying A-SVGD to FWI results in enhanced uncertainty estimation in the resulting subsurface images. While the paper shows interesting results, there are some points that should be improved.

1. The main contribution of the paper should be outlined more clearly. From my perspective, the main contribution lies in the application of A-SVGD to FWI and the respective simulation results of this approach. A large part of the paper is focused on the simulation results, showing that not much new theory or algorithmic developments are proposed in this paper. It should be stated clearly in the introduction that A-SVGD is not proposed by the authors but that the authors use this method to enhance variational inference-based FWI. The respective reference (D'Angelo and Fortuin [2021]) should be cited accordingly in the introduction. Otherwise, the reader will have the impression that A-SVGD itself is part of the contribution.
2. I noticed that parts of Section 2.3, where the A-SVGD is introduced, have been written in a very similar way to that in the original A-SVGD paper D'Angelo and Fortuin [2021]. Especially this paragraph: "A first exploratory phase, dominated by a strong repulsive force (α close to 0) that disperses the particles from their initial positions, facilitating broad coverage of the target distribution. This is followed by a second exploitative phase, where the driving force dominates (α close to 1) and concentrates the particle distribution around different modes..." The authors should not reproduce and reformulate the text from the cited paper but come up with their own explanation and interpretation.
3. Notation:
    1. Introduce the notation of expected value in Eq. (2): e.g., expected value over pdf q wrt. random variable m
    2. Introduce the kernel function k in Eq. (4)
4. Add some comments on which kernel is more beneficial for which situations in SVGD at the end of Section 2.2
5. I would suggest adding pseudo-code of the complete A-SVGD FWI algorithm at the end of Section 2. This gives a better overview of the method.
6. Results:

 doi.org/10.32388/KF7VQC

1. Add the definition of SNR in Fig. 2; it can also be confused with SNR on observed data. Maybe choosing another name would be better.
2. In Fig. 2, the tanh RBF has a higher misfit but a higher SNR; give some reasons.
3. Add a comment on why you chose the initial distribution for the standard deviation to be < 150 m/s in 3.3. Why not higher?
4. Explain the color code of the line graphs in Fig. 7

Declarations

Potential competing interests: No potential competing interests to declare.