# Response to referee 3's comments

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The authors thank the reviewers for the constructive comments and suggested improvements. A revised version of the paper has been prepared considering the reviewers' comments. A list of replies to the reviewers' comments is reported below.

## RC3

### RC3 a)

**The computational cost associated with each simulation or response function (damping ratio) evaluation should be included.**

The authors thank the reviewer for this comment that would improve the case for using surrogate models. The computational cost associated with each HAWC2 simulation is included in the first paragraph of section 3 by adding the following lines

"While a typical HAWC2 simulation takes around 20 minutes, CFD simulations typically take much larger computational time. Additionally, the complexity of setting up the simulations is higher than HAWC2 simulations. For an initial domain exploration, it is advantageous to use solvers like HAWC2, which is still costly for a 5-dimensional problem. The initial exploration results can help decide the focus of higher fidelity CFD simulations and lifting line methods that can be used for a detailed study of the instabilities. "

### RC3 b)

**The threshold used for the termination of the exploration phase is provided as $\epsilon = 0.8$ in Line 266. Generally, the value of $R^2$ used for surrogate modelling is 0.95-0.99. The author needs to provide reasoning for selecting this value of 0.8**

The authors acknowledge that the threshold of 0.8 is rather low, but the considered problem is in 5 dimensions, and surrogate model is trained on a few points (of the order of $10^2$). Hence the surrogate model is expected to have accuracy in this range, and having an accuracy of the order of 0.95-0.99 would require a lot more simulations and consequently, more computational effort.

The following line has been added at the end of section 4.3.1

"The threshold on $R^2$ is set with the consideration that the considered problem is in five dimensions and the number of points is of the order of $10^2$. A higher threshold would require a higher number of simulations and hence incur a higher computational cost. "

## RC3 c)

**The sentences in Section 4.3.3, line 284-286, are unclear. "For every predicted minima, the corresponding Delaunay simplex with the closest centroid is identified, and 285 the value of the target function is evaluated at the vertices of the simplex. A threshold is then set on the average of the vertices values. The predicted minima that do not meet this criteria are regarded as possibly false, and are not considered as samples for the next round."**
**a. What does false mean here? Does it mean inaccurate? The reasoning for not utilizing the already evaluated responses at these predicted minima even though it does not satisfy the threshold needs to be appropriately explained**

The authors thank the reviewer for pointing out the unclear parts of the paper.

The first line of section 4.3.3 has been modified to read

"Because the surrogate model is only an approximation to the true target function, the minimum value predicted by the surrogate model and the value of the target function at the predicted minima may not be the same, and thus the surrogate model predicts many 'false' minima. The predicted minima are false in the sense that the value of the target function at these points are not as low as predicted by the surrogate model"

The sentences of the first paragraph towards the end have been modified to read

"For every predicted minima, the corresponding Delaunay simplex with the closest centroid is identified, and the value of the target function is evaluated at the vertices of the simplex, and the average is calculated ($f_{D,\text{avg}}$). A threshold is then set on $f_{D,\text{avg}}$. The predicted minima whose $f_{D,\text{avg}}$ is higher than the threshold are regarded as possibly false, as they are surrounded by points with a high average value of the target function. Such predicted minima are not considered as samples for the next round."

## RC3 d)

**This study presents a sampling approach based on exploration and exploitation by utilizing the Delaunay triangle, which is one of the main contributions, as mentioned in lines 61-63. The performance of this approach has been compared with expected improvement-based EGO. It would be better for the readers to see the actual comparison of the main application problem related to the SIV of wind turbine blades presented in this study.**

The EGO algorithm has been tried on the main application problem, and the results are presented in figure 10. An accompanying paragraph with the figure has been added at the end of section 4.5

"The EGO algorithm has been run only for 20 iterations from the initial 100 samples but it is to be noted that the EGO algorithm identifies one new sample per iteration, and hence takes a much longer time compared to the framework proposed in this work which identifies multiple samples per iteration. hence, while the proposed framework and the EGO algorithm have been run for nearly the same amount of time, the EGO algorithm uses much fewer samples. Also, the focus of the EGO algorithm is to identify the global minimum, while the focus of the framework presented in this work is to also obtain a surrogate model that identifies multiple critical regions in the domain. Thus the feature that the proposed framework uses many samples is of great advantage since the surrogate model is trained better."

## RC3 e)

**Multiple runs of the presented approach are provided for analytical problems; however, it is not provided for the main application, which is the optimization regarding the SIV. The algorithm's robustness to initial samples and runs should also be demonstrated for the main application problem.**

The authors thank the reviewer for this suggested enhancement which would show the robustness of the proposed framework better. The framework is tested on a different initial sample set, and the results are shown in the appendix.

## RC3 f)

**The authors should also shed some light regarding the non-monotonic convergence of the damping ratio in Figure 8-b. For example, what optimizer (algorithm) was used, and does the non-monotonic convergence trend depend on the optimizer?**

The following lines have been added in section 4.3.2 to include information about the optimizer that has been used.

"Many choices for the minimization algorithm exist, and in this work the minimization was performed using the Sequential Least SQuares Programming (SLSQP) algorithm [1]. The minimization using SLSQP algorithm is implemented using the Python library `SciPy` [2]."

The reason for the non-monotonic trend of the convergence is that, as stated in section 4.3.3 of the paper, the minimum predicted by the surrogate model and the actual minima obtained from simulations is not the same.

This point has been included in the first paragraph of section 4.5 which now reads

"It can be seen that during the convergence, the minimum does not keep decreasing sequentially with iterations. The reason for this non-monotonic trend is that, as mentioned in section 4.3.3, the minimum damping ratio predicted by the surrogate model and the actual damping ratio from HAWC2 simulations do not always agree."

## RC3 g)

**In Section 5, the influence of variables on SIV is studied using Sobol Indices-based global sensitivity analysis. While the first-order and second-order Sobol indices are provided, it's recommended to also include the total order Sobol Indices that includes information regarding the individual and mixed-order interactions/ contributions of the input variables.**

The authors thank the reviewer for this recommendation that would help in an enhanced inference of the Sobol indices. The total Sobol indices have been included in table 4 in section 5, and the following sentence has been added at the end of section 5.

"This can also be seen from the values of the total Sobol indices shown in table 4 which include the combination of first, second and all the other higher order indices"

# References


[1] D. Kraft, "A software package for sequential quadratic programming," *Forschungsbericht-Deutsche Forschungs- und Versuchsanstalt fur Luft- und Raumfahrt*, 1988.

[2] P. Virtanen, R. Gommers, T. E. Oliphant, M. Haberland, T. Reddy, D. Cournapeau, E. Burovski, P. Peterson, W. Weckesser, J. Bright, S. J. van der Walt, M. Brett, J. Wilson, K. J. Millman, N. Mayorov, A. R. J. Nelson, E. Jones, R. Kern, E. Larson, C. J. Carey, İ. Polat, Y. Feng, E. W. Moore, J. VanderPlas, D. Laxalde, J. Perktold, R. Cimrman, I. Henriksen, E. A. Quintero, C. R. Harris, A. M. Archibald, A. H. Ribeiro, F. Pedregosa, P. van Mulbregt, and SciPy 1.0 Contributors, "SciPy 1.0: Fundamental Algorithms for Scientific Computing in Python," *Nature Methods*, vol. 17, pp. 261–272, 2020.