Review of *Model Adaptivity for Goal-Oriented Inference using Adjoints*

The authors present an algorithm for adaptive model refinement in an inference problem with the focus on predicting a quantity of interest (QoI). A hierarchy of models is considered; higher-fidelity models are only used where influential to the QoI of inference process (i.e. near observation data), and lower-fidelity models are used in the remainder of the domain. To determine where a high(er)-fidelity model is needed, the authors rely on (model) error estimates based on the solution of an adjoint problem related to the QoI. Following the mathematical foundation and description of the algorithm, the authors present three numerical experiments that demonstrate the effectiveness of the method on different categories of problems.

Overall the manuscript is well written. A unique approach for model refinement is presented; the contributions of this work are clearly distinguished from the cited works. The theory is presented in a straightforward manner and adequately supported with explanations and citations. The examples are well thought out, covering different areas of application, and building naturally on one another. With some minor adjustments/suggestions described below, I feel that this manuscript is suitable for publication in Computer Methods in Applied Mechanics and Engineering.

Minor concerns/comments:

(a) On page 8 (before equation 10), the sentence "Note that, .." references equation 11 before it is presented. It may be better to move this comment to immediately follow the description of equation 11.

(b) I found the motivation in the beginning of the manuscript somewhat lacking. The description of use cases, and conditions for which the algorithm is suitable, from the last paragraph on page 9 were very helpful. I believe the presentation would be strengthened by mentioning some of this earlier in the introduction.

(c) Although it is represented graphically in Figure 8, Ω_I for the final example is not defined in the text.

(d) At the beginning of the second paragraph of Section 4.3.2 (pg. 25) I think the reference to "Section 4.3.2" should be Table 1.

(e) The sub-figures of Figure 9 could be larger. It is difficult to verify the claim in the text that "...the domain is refined completely in the x_3 direction first around the QoI region...". Even going as far as to include 2-D slices (as in Figure 8) may be warranted.

(f) The second to last paragraph on page 28 starts "Section 4.3.2 shows the average QoI...". Again, I believe this is a reference to a table, Table 2 in this case.

(g) I find the potential to apply this approach to surrogate design, as discussed in the final paragraph, very interesting. I believe this is a good case for overcoming the cumulative cost of performing multiple adaptive steps where the overall cost is comparable to evaluating the high-fidelity inverse problem. If the final adaptive step was significantly cheaper to evaluate (say 2X as in the last example) the cumulative cost of the adaptive algorithm would be amortized across a large number of posterior samples with the final mixed-fidelity model.