**IEEE Open Journal of Antennas and Propagation**

**Response to Reviewers for Manuscript ID:** OJAP-0169-2025

**Original Article Title:** “Ray-Tracing Based RIS Deployment Optimization for Indoor Coverage Enhancement”

Dear Editor,

We sincerely thank the Editor, Associate Editor, and Reviewers for their time, thoughtful feedback, and the opportunity to resubmit our manuscript. We have carefully addressed all comments and revised the manuscript accordingly.

We are submitting the following files:

(a) this point-by-point response to the reviewers’ comments,

(b) a revised manuscript with changes highlighted in yellow, and

(c) a clean version of the revised manuscript without highlights.

Best regards,

Emre Kilcioglu and Claude Oestges

**Reviewer 1:**

*This paper proposes a novel ray-tracing based joint optimization framework that simultaneously determines the RIS position, size, and target points to enhance indoor coverage, especially in blind spots due to blockage. The proposed method leverages ray-tracing simulations to provide physically consistent optimization based on a selected NLOS communication environment. The simulation results for different simulation parameters in an indoor office environment are reported, demonstrate that the improvement performance of coverage and signal quality in blind spots by optimizing RIS deployment parameters.*

*The paper is generally well structed and written, and presents a clear and concise description of the proposed method. Hence, the reviewer is rather positive to accept this paper after revisions. However, the reviewer wants to raise some important concerns, especially in the significance and detailed implementation of the paper.*



**Reviewer 1 - Comment 1:** *In page 3, section 2, the authors choose the NVIDIA’s open-source Sionna ray-tracing tool, can authors add some description compared with other RT tools, like, Wireless insite, to specify the advantage and efficiency of the Sionna.*

**Author response:** We thank the reviewer for this suggestion. We have added a comparative discussion at the beginning of Section II to clarify the reasoning for choosing Sionna RT over other commercial ray-tracing tools such as Wireless InSite. While both tools rely on physically consistent ray-tracing models, Sionna offers two key advantages: (1) it is fully open-source and customizable, allowing us to adapt the internal architecture and propagation settings to our RIS optimization framework, and (2) it supports GPU acceleration through TensorFlow, enabling us to process tens of thousands of rays in parallel, which significantly reduces simulation runtime. By contrast, Wireless InSite is closed-source, CPU-bound, and requires a commercial license. We believe this change better motivates our software selection and aligns with the reproducibility goals of the research.



**Reviewer 1 - Comment 2:** *The authors utilized two methods to determine the reflection behavior of the RIS, authors are suggested to provided some figures, like simulation result, to specify the features and differences of the two methods.*

**Author response:** We thank the reviewer for this insightful comment. The two phase-profile design methods are described at the beginning of Section III of the manuscript.

* Gradient-based, which introduces a linear phase ramp across the RIS surface to steer reflections in a desired direction, based on the difference between the incident and reflected wave vectors;
* Distance-based, which aligns the total propagation path length (TX-RIS-target) at each tile to focus energy precisely at the target point.

While their effects on performance are already compared both analytically and visually in Section V through coverage maps (see Figs. 14, 15, 19, and 20 in the revised manuscript), we agree that a direct visual comparison of their phase profiles would enhance understanding. Accordingly, we have added new subfigures to Figs. 14 and 15, each showing the per-tile phase profile used in that scenario for each target point. We have also expanded the related discussion in Section V-E-5 to interpret these visualizations. These visualizations clearly distinguish the smooth, linear variation of the gradient-based design from the more focused, nonuniform patterns produced by the distance-based method.



**Reviewer 1 - Comment 3:** *In practical scenario, real RIS prototype typical have initial response for each element. Besides, the RIS typical have limited phase resolution depending on RIS bits. How to add the RIS in RT simulation scenario via Sionna, and it may be different from RIS added into conventional Wireless insite software.*

**Author response:** We thank the reviewer for drawing attention to practical RIS hardware constraints. In our current project, we collaborate with our antenna team, whose prototype uses continuous‐analog varactors. Therefore, we adopt a continuous-phase model in our simulations. NVIDIA Sionna’s ray-tracing module allows users to define an arbitrary two-dimensional array of complex reflection coefficients (both amplitude and phase) directly on each tile (see the Sionna RIS modeling documentations linked below). This modeling approach was already described starting from the third paragraph of Section II.

Discrete, bit-quantized RIS implementations can also be modeled by quantizing the continuous phase values to discrete levels based on the number of control bits (e.g., quantizing to the nearest 2π divided by 2^b for a b-bit RIS). Sionna then applies these per-tile coefficients during ray tracing without further approximation.

To better emphasize this modeling flexibility and its practical relevance, we have revised and clarified the third paragraph of Section II.

Related documentation of the Sionna RT regarding RIS modeling:

<https://jhoydis.github.io/sionna-0.19.2-doc/em_primer.html>

<https://jhoydis.github.io/sionna-0.19.2-doc/api/rt.html#reconfigurable-intelligent-surfaces-ris>



**Reviewer 1 - Comment 4:** *The optimized parameters are calculated based on simulated coverage map, which requires modeling for actual scenario and exhaustive simulation, which may lead to large computation cost and overhead, especially for scenarios with many scatterers. So did the method have adjustable resolution, and did it influence the algorithm accuracy?*

**Author response:** We thank the reviewer for pointing out the important trade-off between simulation resolution and computational load. The Sionna RT coverage map module as implemented in the Scene.coverage\_map() method (see the link for the coverage map documentation of Sionna RT below) provides several adjustable parameters that control the fidelity, granularity, and runtime of the coverage map calculation. The most relevant parameters include:

* max\_depth: the maximum number of path bounces (reflections) considered per ray
* cm\_cell\_size: the size (in meters) of each grid cell in the coverage map
* num\_samples: the total number of rays traced during simulation

Increasing the number of samples or decreasing the cell size results in higher-resolution and more accurate maps, at the cost of longer simulation times. In our study, we selected: max\_depth = 6, cm\_cell\_size = [0.4, 0.4] meters, and num\_samples = 20,000,000, which we found to provide a good balance between simulation granularity and runtime.

We emphasize that these parameters only affect the ray-tracing output and do not change anything related to the optimization algorithm we propose. Regardless of the coverage map resolution, our algorithm consistently identifies low-power cells, determines RIS target points, and optimizes the RIS configuration accordingly. We have added a new paragraph in the Simulation Parameters subsection of the manuscript to clarify these parameter choices.

Coverage map documentation of Sionna RT:

<https://jhoydis.github.io/sionna-0.19.2-doc/api/rt.html#coverage-maps>

<https://jhoydis.github.io/sionna-0.19.2-doc/api/rt.html#sionna.rt.Scene.coverage_map>

**Reviewer 1 - Comment 5:** *The authors are suggested to list key parameters (like frequency, transmit power, RIS grid size, power threshold, etc.) in a table. Also, based on simulation results, the authors are suggest to provide a general guideline for the RIS location, size, and beamforming method.*



**Author response:** asdasd**Reviewer 1 - Comment 6:** *Many RIS prototypes are designed to orthogonally polarized, which means the incident wave and reflected wave of the RIS are orthogonally polarized due to its design. Do you consider this issue, how to handle this issue in RT software?*



**Author response:** asdasd**Reviewer 1 - Comment 7:** *Do you consider the height of the RIS? The height of the Tx, RIS, and Rx may influence the coverage performance of RIS-aided systems due to difference of reflection paths.*



**Author response:** asdasd**Reviewer 1 - Comment 8:** *The authors are suggested to provide more take-home message in conclusion, such as the guideline for the RIS location, size, and beamforming method for the selected scenario based on the simulation results.*



**Author response:** asdasd



**Reviewer 2:**

*This paper proposes a ray-tracing framework for optimizing RIS deployment in indoor environments, focusing on joint design of position, size, and target points. While the topic is timely and the problem formulation has merit, the reviewer finds the current presentation and technical execution to require further refinement. Key concerns include insufficient motivation for methodological choices, limited validation of assumptions, and ambiguities in interpreting critical figures.*



**--Reviewer 2 - Comment 1:** *\*\*[Page 4, Eq (1)]\*\**

*The reflection coefficient model for a single tile (RIS element) assumes a fixed amplitude profile. However, the reviewer notes that this may not fully account for practical considerations. While passive RIS elements inherently lack active amplification, their amplitude response can still exhibit angular dependency due to variations in incident angles. To enhance model accuracy and better reflect the directive properties of RIS, the authors are encouraged to incorporate angular-dependent attenuation effects into the reflection coefficient design. This adjustment would strengthen the alignment with real-world RIS behavior.*

**Author response:** asdasd**Reviewer 2 - Comment 2:** *\*\*[Page 5, Sec III.A]\*\**



*The Gradient-Based Phase Profile design requires further clarification to improve readability. Specifically, the derivation of the incident phase gradient in Eq. (2) and its relationship to the final phase shift design are not explicitly detailed. The authors are advised to expand this section by explicitly connecting the phase gradient concept to the implemented phase shifts (e.g., through mathematical steps or a design framework). This would help readers better understand the methodology and its theoretical underpinnings.*

**Author response:** asdasd**Reviewer 2 - Comment 3:** *\*\*[Page 5, Eq (12)]\*\**



*The distance-based phase profile model assumes constructive interference occurs when total propagation distances are equal. However, this may oversimplify practical scenarios. Due to the periodic nature of phase shifts, constructive interference could occur even with unequal distances. Additionally, environmental interactions (e.g., multipath effects) may lead to longer effective propagation paths. The authors are encouraged to revisit this model to account for these factors, ensuring it captures both phase periodicity and environmental propagation effects.*

**Author response:** asdasd**Reviewer 2 - Comment 4:** *\*\*[Page 7, Algorithm 2]\*\**



*The algorithm employs an exhaustive search to determine the optimal RIS width. While effective for the presented simulations, this approach may face scalability challenges in scenarios with unpredictable or wide-ranging candidate values. The authors should discuss the computational complexity of this method and propose strategies to enhance scalability (e.g., heuristic optimizations or theoretical bounds to narrow the search space). Such additions would better motivate the algorithm’s practicality for real-world deployment.*

**Author response:** asdasd



**--Reviewer 2 - Comment 5:** *\*\*[Page 10, Figure 7]\*\**

*The relationship between RIS dimensions and performance could be more clearly presented. Since tile size is fixed, for a larger height, the same expansion in width can leads larger number of additional tiles thus a better performance can be well expected. The reviewer believes directly correlating the number of tiles (elements) to the performance metric would improve interpretability. Additionally, the unit of the performance metric currently uses dB, which is not a correct unit for power. Clarifying this would avoid potential confusion.*

**Author response:** asdasd



**--Reviewer 2 - Comment 6:** *\*\*[Page 10, Figures 8 & 9]\*\**

*The interpretation of these figures requires further elaboration. The impact of parameter N on performance is not explicitly discussed, making it challenging to understand the figure. The authors should provide a clearer explanation of the trends, including axis labels, annotations, or a brief discussion linking N to the observed results. This would significantly enhance the figures’ value to readers.*

**Author response:** asdasd

