# Apeks: Wi-Fi coverage mapping with kriging interpolation and router placement optimization

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## Introduction

Fast and efficient wireless connections are no longer a luxury but a necessity. Researchers have increasingly investigated optimal router placement strategies to address demands for reliable indoor wireless coverage. This problem requires understanding of both wireless communications and spatial modeling, making knowledge of indoor mapping and Wi-Fi signal analysis essential.

Signal strength is quantified using the Received Signal Strength Indicator (RSSI) (Hegde et al., 2023). RSSI values allow for assessing signal degradation caused by obstacles, distance, and interference.

Indoor environments present unique challenges for wireless coverage due to the complex geometry of walls and furniture. LiDAR scanning provides a method for capturing point cloud maps of partitions, from which structures such as walls are extracted computationally. Random Sample Consensus (RANSAC) can interpret data containing noise and is suited for applications in automated image analysis where data is inherently error prone such as LiDAR point cloud processing (Martínez-Otzeta et al., 2022).

Because LiDAR captures raw spatial geometry and RANSAC robustly extracts structural features from noisy data, wall boundaries can be identified without a pre-existing floor plan. The objective of this project was to develop an automated system capable of mapping interior spaces, analyzing Wi-Fi signal data, and optimizing router placement for improved wireless coverage.

## Methods and Materials

Automated Placement and Estimation using Kriging for Signals (Apeks), an open-source application developed for wireless coverage optimization, was designed and implemented using the iPhone 17 Pro's LiDAR sensor, a GL-SFT1200 wireless router, and a Windows laptop. The system utilized the Stray Scanner iOS application for LiDAR acquisition, while spatial and signal data were stored using JavaScript Object Notation (JSON) and a SQLite database.

Apeks was implemented as two Python applications: ApeksDrawer, a tool that converts raw Stray Scanner LiDAR exports into a JSON floor plan via RANSAC plane fitting, and ApeksMap, a main optimizer providing a workflow for signal collection, heatmap construction, and router placement. Key libraries included GSTools and SciPy for interpolation, Matplotlib for visualization (Figure 2), PyWiFi for RSSI collection, and CustomTkinter for the GUI.

Apeks operated as a three-phase end-to-end pipeline consisting of floor plan extraction, signal collection, and coverage optimization, ultimately producing a router placement recommendation (Figure 1).

## Methods and Materials (continued)

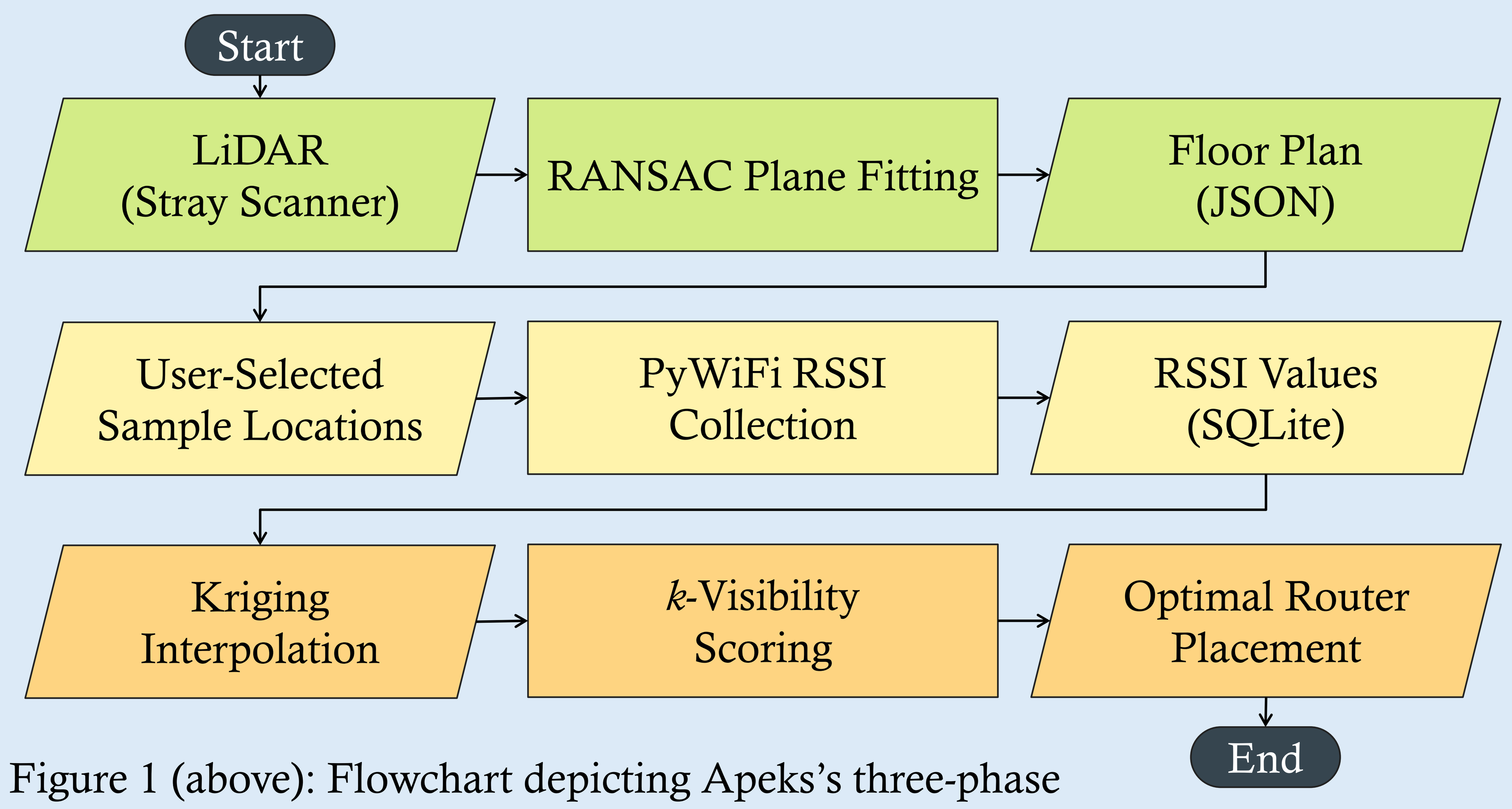
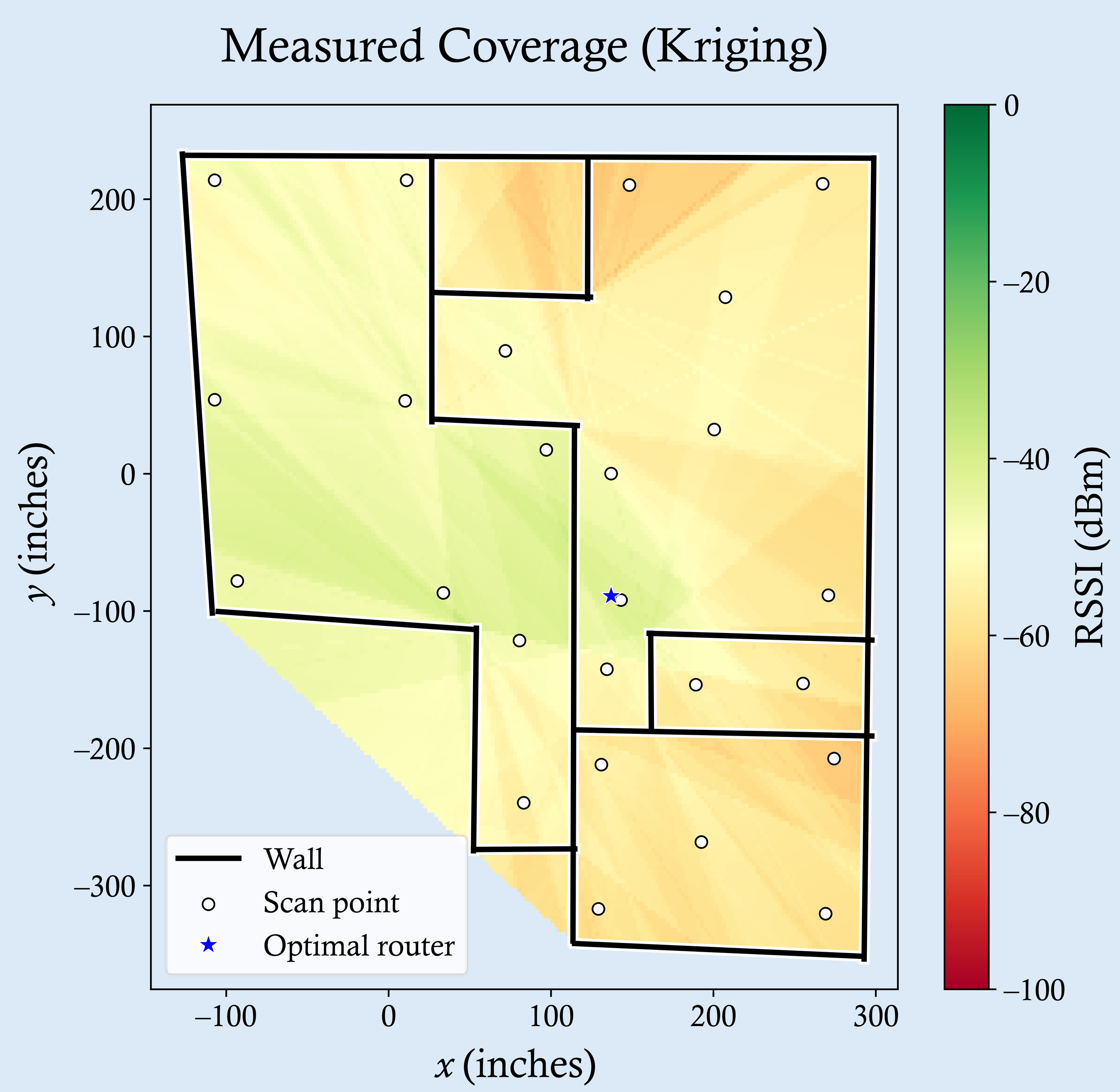



Figure 1 (above): Flowchart depicting Apeks's three-phase pipeline: (1) floor plan extraction using LiDAR scanning and RANSAC plane fitting, (2) signal collection via PyWiFi-based RSSI sampling, and (3) coverage optimization using kriging interpolation and *k*-visibility scoring.



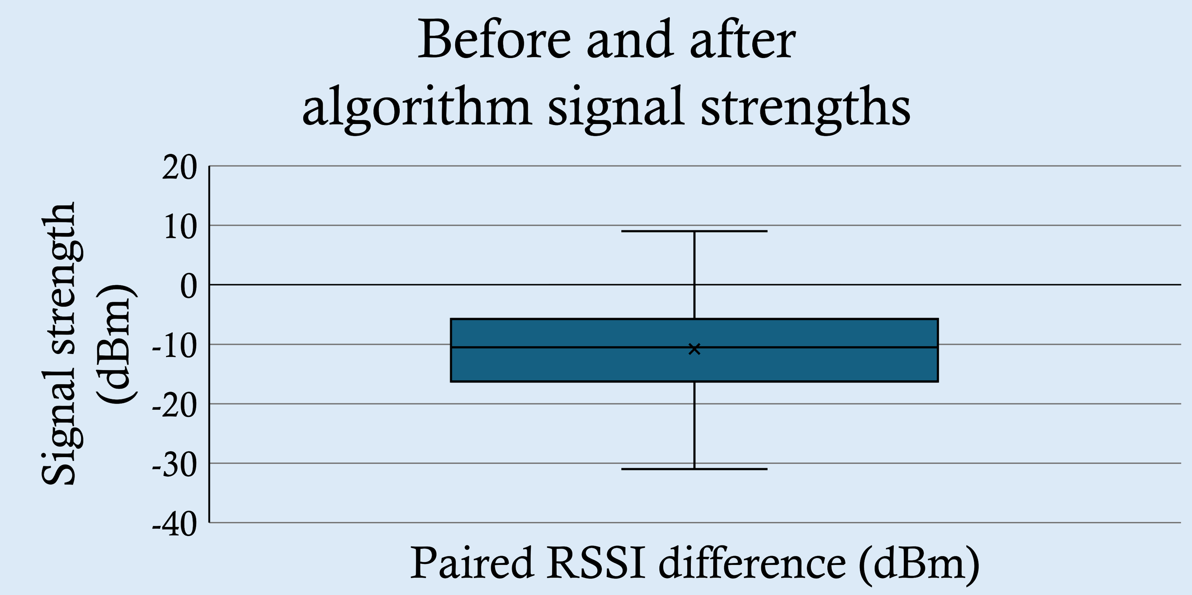

Graph 1 (left): Application-generated wall-aware ordinary kriging heatmap of interpolated Wi-Fi RSSI (dBm) across the floor plan. White markers indicate scan point locations; the blue star denotes the optimal router position, selected by maximizing predicted RSSI across a candidate grid filtered by *k*-visibility.

## Results

Data was collected across 30 scan locations within the mapped space. Because each location captured RSSI readings from all visible wireless networks simultaneously across two trials, this yielded 611 unique entries across the dataset. Signal strength shifted from −64.8 dBm to −54.0 dBm, a 10.8 dBm gain representing approximately 7.2 times the original signal power.

## Results (continued)

Before optimization, the router was placed at a central, visually intuitive location typical of manual placement. Following optimization, a paired sample $t$-test confirmed this difference was statistically significant ($M = -54.0$, $SD = 9.9$) compared to before ($M = -64.80$, $SD = 11$), $t(29) = -5.26$, $p < .001$, 95% CI [−15.00, −6.60]. These results are visualized in a boxplot (Graph 2).




Graph 2 (left): The boxplot displayed Wi-Fi the difference of signal strength before and after application of the router placement optimization algorithm across 30 scan locations ($N = 611$).

## Conclusion

Apeks demonstrated the practical value of combining spatial mapping with wireless signal analysis to address inconsistent Wi-Fi coverage. The statistically significant improvement in signal strength supports the conclusion that algorithmic router placement outperforms arbitrary router placement, establishing Apeks as a viable free alternative to hiring a specialist. Deeper familiarity with signal propagation algorithms would have accelerated development and likely more refined interpolation.

The project has meaningful room for growth, however. RANSAC-based wall extraction required manual correction in complex environments, testing did not evaluate features such as zone priority weighting, and support for multiple routers and multi-floor environments would substantially increase real-world applicability. With considerable work remaining, Apeks is a proof of concept rather than a true commercial alternative.

## References

Hegde, R., Hegde, S. K., Prasad, K., Srinivas, V., De, T., & Gowda, V. D. (2023). Wi-Fi router signal coverage position prediction system using machine learning algorithms. *2023 International Conference on Sustainable Computing and Smart Systems*, 253–258. https://doi.org/10.1109/ICSCSS57650.2023.10169501

Martínez-Otzeta, J. M., Rodríguez-Moreno, I., Mendialdua, I., & Sierra, B. (2023). RANSAC for robotic applications: a survey. *Sensors*, *23*(1), 327. https://doi.org/10.3390/s23010327