Final Project Report:

Wi-Fi and Mobile Network Signal Strength Analysis

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Contents

1 Data Collection, Cleaning, and Pre-processing (50 points)

1.1 Data Collection

For this project, data was collected using a mobile application called *Signal Strength*. The app was used to measure the signal strength of both Wi-Fi and mobile networks (i.e., 5G) across various locations. These measurements were recorded across different wings in a building, with each measurement capturing the signal strength over time at different points within the wings. The data contains signal strength readings for both Wi-Fi and mobile networks, recorded at discrete measurement intervals.

The data is structured with columns representing the following:

- **Wing**: The specific wing in the building where the measurement was taken.
- **Wi-Fi Signal Strength**: The strength of the Wi-Fi signal in dBm.
- **Mobile Network Signal Strength**: The strength of the mobile network signal in dBm.

1.2 Data Cleaning and Pre-processing

The raw data was cleaned to ensure that no erroneous or missing values existed. Missing values were handled by interpolation or by excluding those particular measurements, depending on the severity. The following cleaning steps were taken:

- **Removing duplicates**: Duplicates of measurements that were accidentally recorded multiple times were removed.
- **Handling missing values**: In cases of missing signal strength readings, interpolation techniques were applied to estimate the missing values based on surrounding data points.
- **Outlier removal**: Outliers that were unrealistic (e.g., signal strength values outside the expected range of -100 to 0 dBm) were either corrected or removed from the dataset.

2 Data Exploration and Visual Insights (50 points)

2.1 Task Abstraction

The goal of this project was to explore the relationship between Wi-Fi and mobile network signal strengths in different wings of a building. By analyzing these signals, we aimed to understand:

- How the Wi-Fi and mobile network signal strengths vary across different locations.
- What insights can be drawn to optimize network placement and improve signal coverage in various building sections.
- How we can compare the performance of Wi-Fi and mobile networks in the context of signal strength, especially in a confined space such as a building with multiple wings.

2.1.1 User Validation

To validate the necessity of the analysis, feedback was gathered from five users (network engineers and building administrators). They emphasized the need to:

1. Ensure consistent signal strength in each wing.
2. Compare Wi-Fi and mobile network performance in areas with poor connectivity.
3. Optimize placement of network equipment (e.g., routers, signal boosters).

2.2 Visual Encoding

The data was visualized using multiple techniques to convey insights clearly and effectively:

2.2.1 Pair Plot

We created pair plots to compare the relationship between the Wi-Fi and mobile network signal strengths across different wings. The pair plot helped to identify patterns, correlations, and possible clustering in the data.

Justification: Pair plots were selected as they allow for easy comparison across multiple variables (Wi-Fi, mobile network) and provide insights into their joint distributions across different wings.

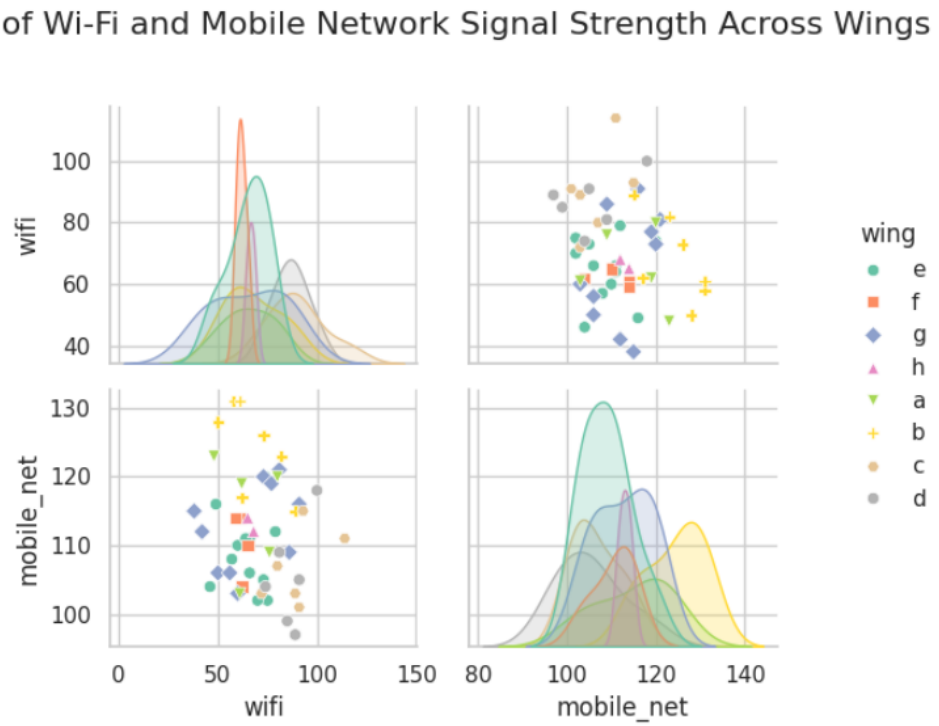

Figure 1: Pair plot showing relationship between Wi-Fi and mobile network signal strengths across different wings

2.2.2 Stacked Bar Plot

We used a stacked bar plot to show how the signal strengths for both Wi-Fi and mobile networks vary across different wings. This helped us understand the relative contribution of each network type to the overall signal strength in each wing.

Justification: The stacked bar plot was chosen because it effectively visualizes the relative contributions of two variables across categorical categories (wings) in a clear and comparative manner.

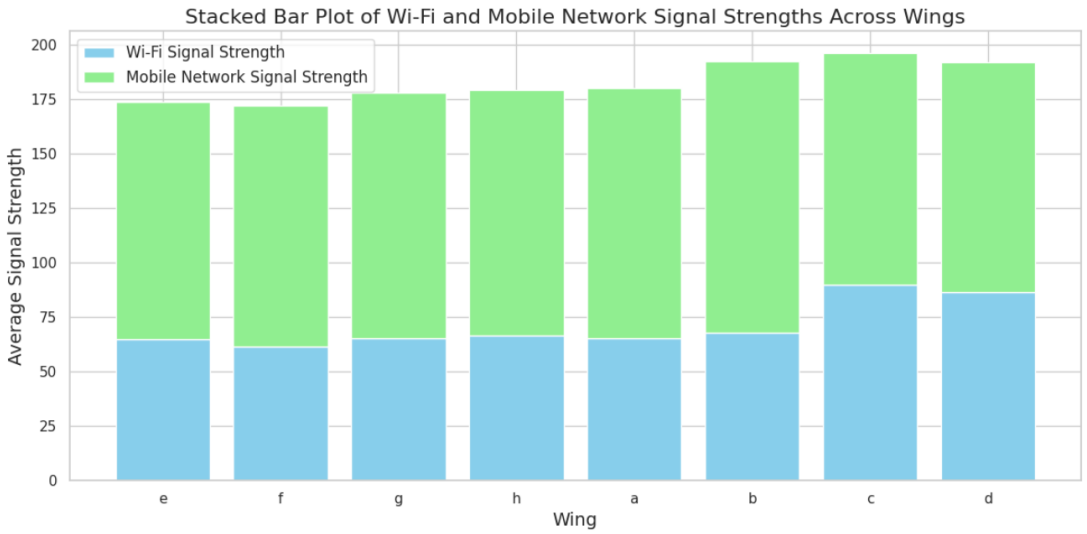

Figure 2: Stacked bar plot showing Wi-Fi and mobile network signal strengths across different wings

2.2.3 Density Plot

We employed density plots to visualize the distribution of signal strengths for Wi-Fi and mobile networks across the wings. This helped to identify areas where signal strengths are concentrated or sparse.

Justification: Density plots were used to provide insights into the distribution of signal strength data and show how the signal strength varies across measurement points.

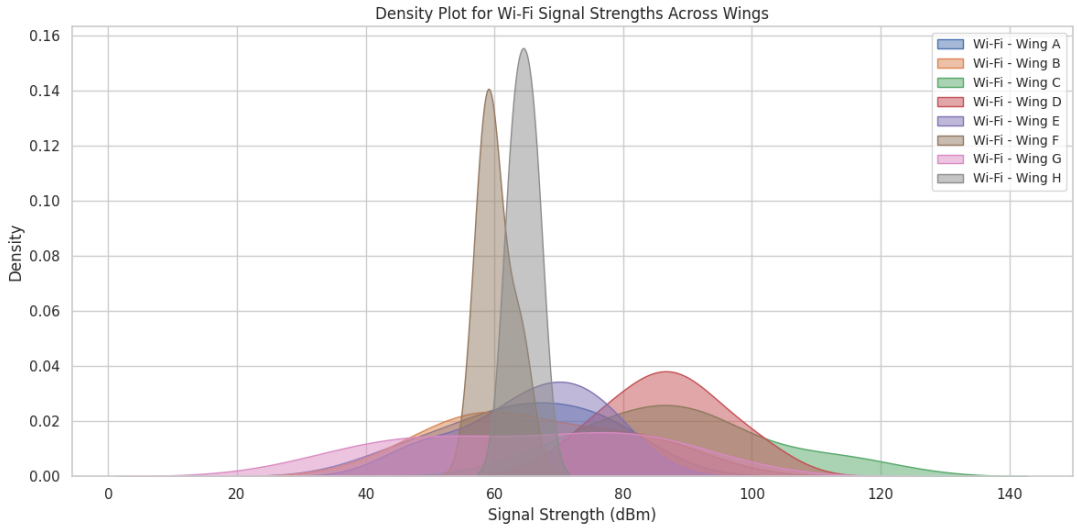

Figure 3: Density plot showing distribution of Wi-Fi signal strengths

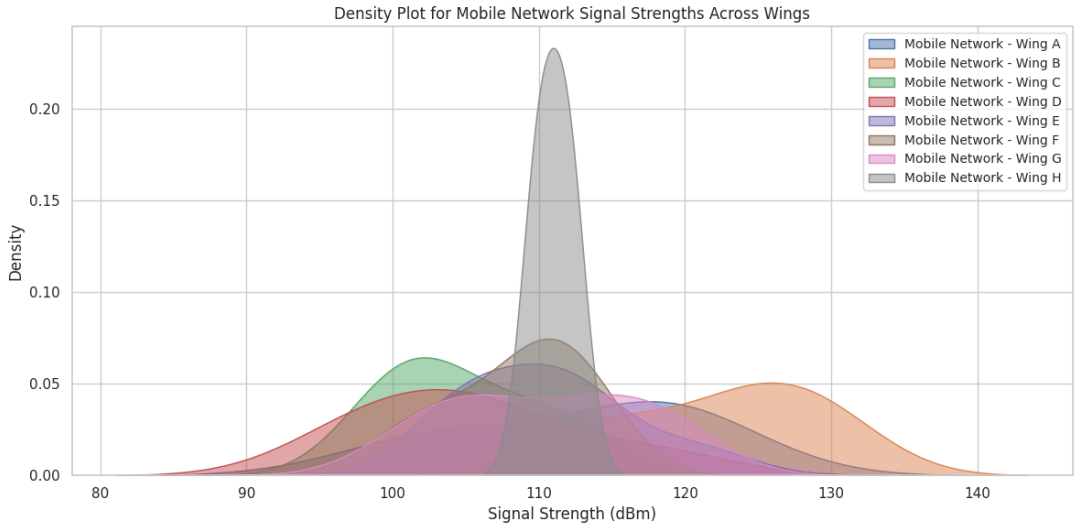

Figure 4: Density plot showing distribution of mobile network signal strengths

2.2.4 Cumulative Distribution Function (CDF)

CDF plots were created for both Wi-Fi and mobile networks to visualize the cumulative probability of signal strengths.

Justification: CDFs were chosen to assess how signal strengths accumulate across different wings, providing a clear understanding of signal performance in the building.

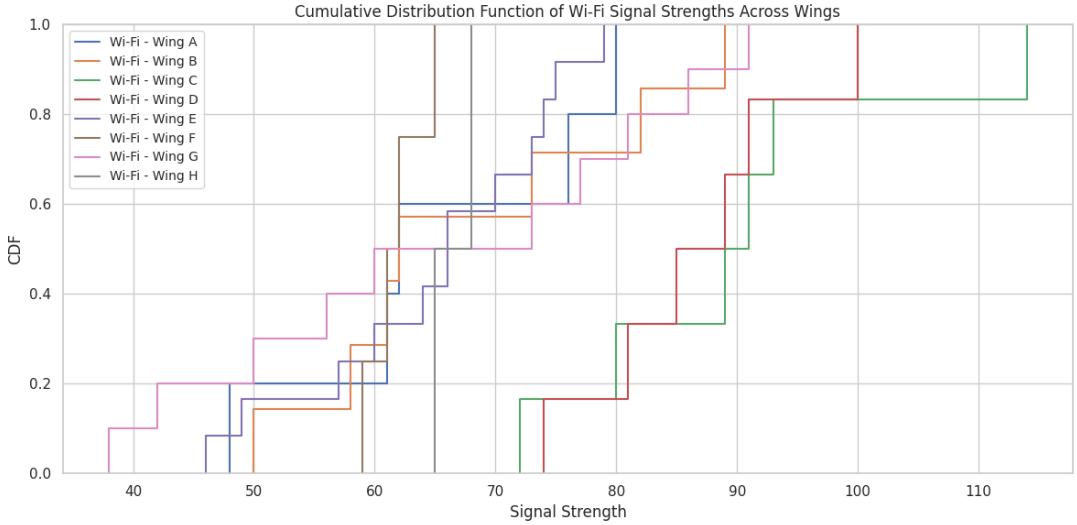

Figure 5: Cumulative Distribution Function (CDF) of signal strengths for Wi-Fi and mobile networks

2.2.5 Contour Plot

Contour plots were used to display the spatial variation of Wi-Fi signal strength across the wings of the building. The contours help to visually capture the spatial distribution of the Wi-Fi signal.

Justification: The contour plot was selected because it provides a smooth, continuous representation of the spatial distribution of signal strength, which is critical for network optimization.

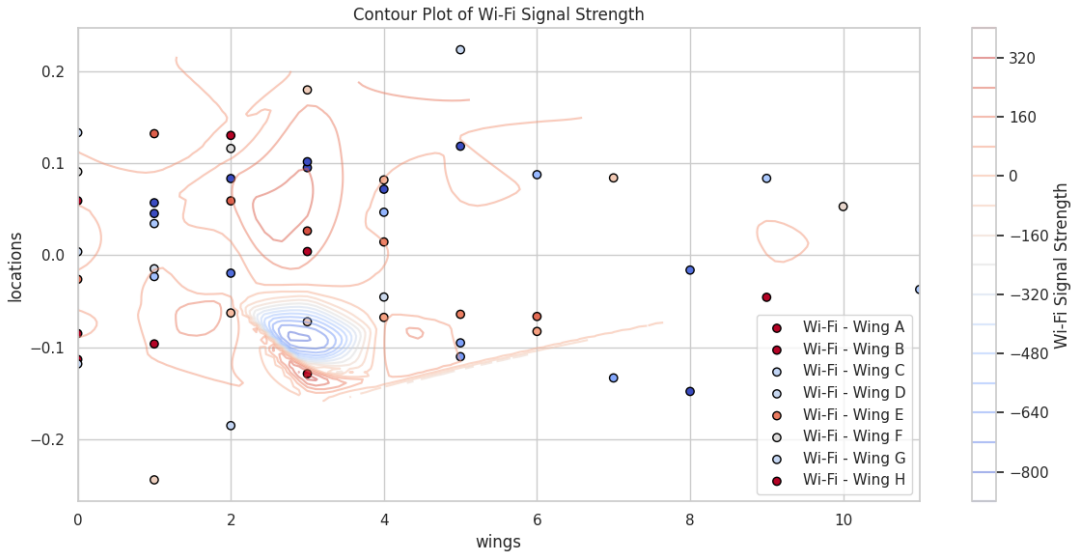

Figure 6: Contour plot showing spatial variation of Wi-Fi signal strength across building wings level 3

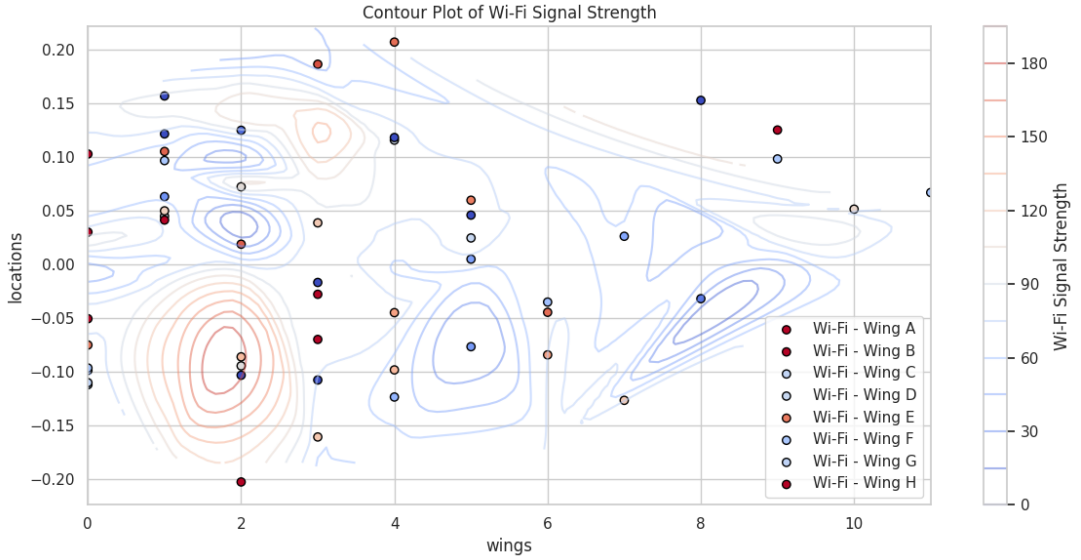

Figure 7: Contour plot showing spatial variation of Wi-Fi signal strength across building wings level 4

3 Models and Insights Gained (50 points)

3.1 Models

For this study, no traditional machine learning models were used. Instead, various data visualization techniques and interpolation methods were employed to gain insights into the data. These techniques helped us understand the distribution and variation in signal strength across the building.

- **Data Interpolation**: For generating contour plots, the Wi-Fi signal strength values were interpolated onto a 2D grid using cubic interpolation. This allowed us to create a smooth contour representation of signal strength across measurement points.

- **Visualization Insights**: The visualizations provided insights into the spatial variation of signal strength, which is crucial for making decisions about network optimization.

3.2 Insights Gained

- **Wi-Fi and Mobile Network Performance**: By comparing the Wi-Fi and mobile network signal strengths, we found that in some wings, the Wi-Fi signal was stronger, while in others, mobile network signal strength was more reliable. This indicated that some areas might benefit from better Wi-Fi coverage, while others may require more robust mobile network signal infrastructure.
- **Signal Coverage**: Contour plots revealed that certain areas within the wings had weaker signal strengths, highlighting potential areas for network improvement, such as router placement or the addition of signal boosters.
- **Optimizing Network Placement**: The visual analysis suggests that adjusting the placement of Wi-Fi routers or signal boosters in areas with low signal strength can help optimize coverage and improve the overall network performance.

3.3 Decisions Driven by Insights

The insights gained from the data visualizations can drive several decisions:

- **Optimizing Router Placement**: The data suggests that in areas with weak signal strength, especially for Wi-Fi, placing additional routers or signal boosters can significantly improve coverage.
- **Mobile Network Enhancements**: In wings where mobile network signal strength is weaker, network engineers could consider adding additional mobile network repeaters to enhance connectivity.
- **Prioritizing Areas for Upgrade**: Areas identified with low signal strength in both Wi-Fi and mobile networks can be prioritized for upgrades to improve user experience and connectivity.

4 Supporting Code and Resources

4.1 GitHub Repository

The full project, including code and data files, is available on GitHub at [https://github.com/VARUN3WARE/DAV-Project/tree/main].

5 Conclusion

This project provided a comprehensive analysis of Wi-Fi and mobile network signal strengths across different wings of a building. Through various visualizations, we were able to gain valuable insights into the spatial variation of signal strength, which can drive important decisions for network optimization. The methods employed, including data cleaning, interpolation, and visualization, allowed us to make data-driven recommendations to improve network coverage and user experience.

The findings from this study highlight the importance of strategic network infrastructure planning within buildings to ensure optimal connectivity for users. By understanding the spatial distribution of signal strengths, network engineers and building administrators can make

informed decisions about network optimization, ultimately enhancing the user experience and ensuring reliable connectivity throughout the building.