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Reflection1

EE 5G8TUT Individual Problems

Comprehensive Analysis of Cellular Network Performance

I was trying to start a thesis under any of my faculty. After talking to several professors, I got a chance to work under Prof. Filippo Malandra, who conducts research in the wireless communication field. I started working at Wireless communication for smart things LAB under the supervision of Prof. Filippo Malandra. At first, I got introduced to Raspberry pi and 5G HAT with the help of the LAB Research Assistant. I was helping him in his Distributed optimization project for smart grid. Gradually I came up with the idea of my own individual project named **"Comprehensive Analysis of Cellular Network Performance"**. I discussed it with my professor, and he suggested a way to start the project by preparing python codes and running the device at various roads of Buffalo. Through this thesis project, I learned how to analyze cellular network performance using key performance indicators (KPIs) such as SINR, RSRQ, and RSRP. I gained hands-on experience in data collection, preprocessing, and visualization using scatter plots and heatmaps. The heatmaps provided a spatial perspective on network performance, allowing me to identify areas of strong and weak signal coverage across three distinct routes: Road 1, Road 2, and Road 3. I also developed a deeper understanding of how environmental factors like urban density and obstructions impact network performance, which is crucial for optimizing network infrastructure [1, 3].

The most helpful aspect of this experience was the integration of quantitative data (from scatter plots) with spatial data (from heatmaps) which developed a clear understanding of network performance. The heatmaps of roads [1, 2, 3] visually highlighted areas of weak signal strength and patchy coverage, which complemented the trends observed in the scatter plots. For example, Road 2's heatmap [2] showed uniformly high signal strength, aligning with its consistently high KPI values, while Road 3's heatmap [3] revealed patchy coverage, correlating with its erratic KPI trends. This combination of quantitative and spatial analysis provided a comprehensive understanding of network performance and offered actionable insights for improvement [4].

I would recommend others to use heatmaps alongside scatter plots when analyzing network performance. Heatmaps provide a geographic perspective that can reveal patterns and anomalies not immediately apparent in quantitative data alone [4]. Additionally, I suggest paying close attention to environmental factors, as they significantly influence signal quality [3]. For those new to heatmap analysis, I recommend starting with smaller datasets and gradually scaling up to more complex analyses. Collaboration with peers and mentors can also enhance the quality of the analysis and interpretation.

This project significantly strengthened my analytical and visualization skills. I became more confident in interpreting spatial data and identifying areas for network optimization. My ability to communicate technical findings effectively also improved, as I learned how to present complex data in a clear and actionable manner. Additionally, I gained a better understanding of the importance of environmental factors in technology, which will be valuable in my future career in telecommunications [1, 3].

One challenge I encountered was ensuring the accuracy of the heatmaps, especially in areas with weak or inconsistent signals. I also faced difficulties in correlating the heatmaps with the scatter plots

initially. The risk I took was integrating multiple types of data (quantitative and spatial) to draw conclusions, which required careful validation to ensure the reliability of the findings. Overcoming these challenges helped me grow both technically and personally [4].

Figure 1: Heatmap of (Road 1) From Winspear Avenue to Rodney Avenue, Buffalo, NY

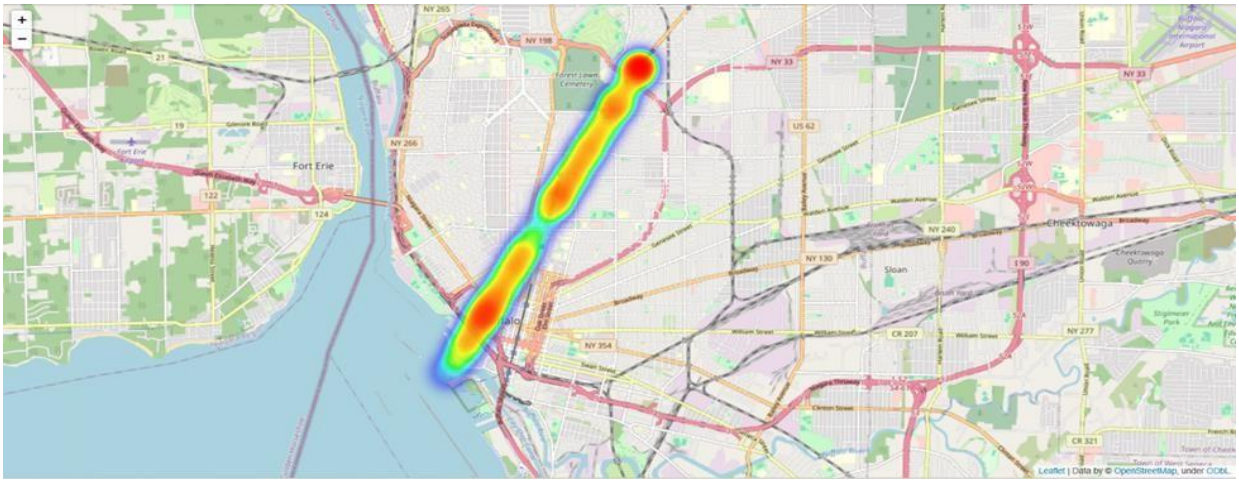

Figure 2: Heatmap of (Road 2) From South Campus Avenue to Downtown Sea.

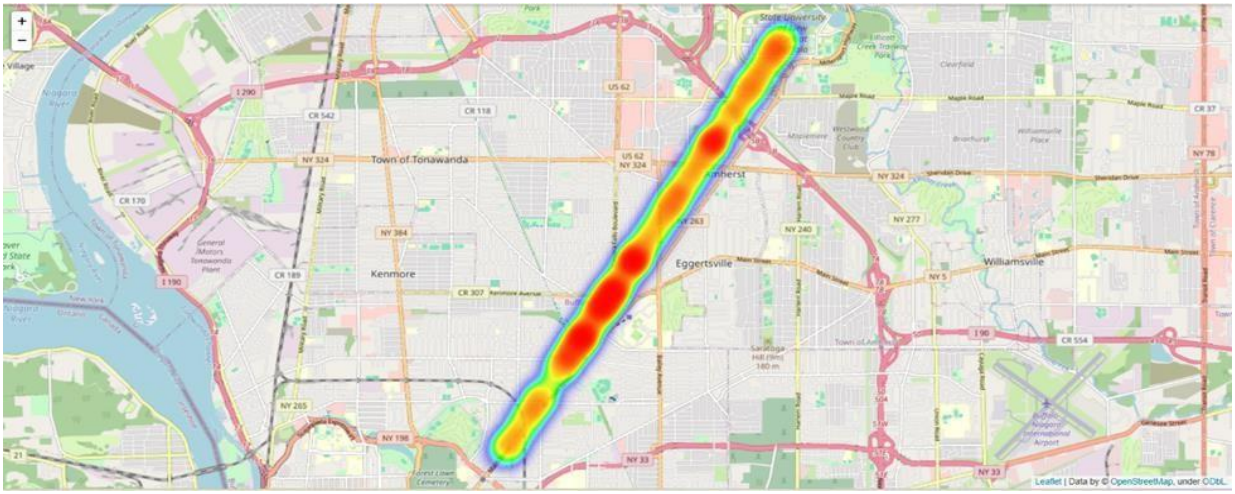

Figure 6 : Heatmap of (Road 3) From South Campus to North Campus UB.

The experience of generating and interpreting heatmaps demonstrated my strengths in data visualization and spatial analysis [4], enhanced understanding of how environmental factors impact network performance [3]. I was able to identify areas of weak signal coverage and correlate them with the quantitative trends observed in the scatter plots. This required both technical skills and critical thinking, highlighting my ability to combine different types of data to draw meaningful conclusions. The project increased awareness of the importance of combining quantitative and spatial analysis for a holistic understanding of network behavior [1, 4]. This skill is essential in network engineering and will be valuable in my future career [4].

In summary, this thesis project was a highly valuable learning experience because it provided me with practical skills in data analysis and visualization that I can apply in my future career. The heatmaps offered a unique perspective on network performance that I found both challenging and rewarding to work with. While there were obstacles, overcoming them helped me grow both technically and personally [1, 3, 4].The experience has prepared me well for future challenges in the field of telecommunications.

References:

1. SINR, RSRP, RSSI, and RSRQ Measurements in Long-Term Evolution
2. IEEE Document on Network Performance Analysis
3. Impact of Environmental Factors on Network Performance
4. Heatmap Visualization in Network Analysis