Team A.L.A.N.

Data Analysis

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1 Introduction

Barcelona, a vibrant and diverse city, is currently the second-most populous municipality in Spain and a major economic center. Its architectural beauty, diverse neighborhoods, and rich culture make it a standout destination for its residents and tourists, with unique experiences around every corner.

However, Barcelona faces many problems relating to traffic congestion, air pollution and environmental sustainability. The city's narrow streets and high population density have contributed to severe traffic jams, making daily commuting a frustrating experience for residents and visitors alike. Traffic congestion also contributes to air pollution, another major concern. Poor air quality in Barcelona has adverse effects on public health and the environment. Addressing this issue is vital to ensure the well-being of the city's inhabitants and to reduce the city's carbon footprint.

Therefore, we recommend our "Uber Bus-Kiosk" system, implementable in Barcelona to alleviate these problems which are faced by the population and solve in coordination with goals aligned with the Barcelona Climate Plan 2018-2030 [9].

2 Problems

2.1 Traffic Congestion

The first issue we attempted to investigate was traffic congestion. However, we did not have traffic congestion and/or volume data for Barcelona. Previous research has supported that areas with a higher population, on average, have more issues pertaining to traffic congestion [1]. Thus we attempted to understand overall population demographics, in order to properly understand traffic congestion in Barcelona. With the provided population data we had a choice between many different years. We assumed that these population counts were taken through a census, and that year to year the population value would fluctuate due to non-sampling error. In order to lower this potential non-sample error, we utilized an average across the years for each district in Barcelona to allow for an overall understanding of Barcelona's population. This visualization showed a high population in Eixample and Sant Marti. In order to get a lower-level understanding of the demographics, we generated a finer-resolution version of this map by instead using neighborhoods. This allowed us to determine that there was indeed a high-population cluster near Eixample. Therefore, there is a greater amount of traffic congestion near Eixample.

However, we considered the possibility that this interpolation concerning population and traffic congestion was inaccurate. In order to pursue this possibility, we considered another approach regarding traffic congestion. Previous research supports that a decrease in traffic volume is associated with a significant reduction in collisions or that areas with a higher collision frequency would have greater traffic volume [2]. By extrapolating this knowledge, we were able to quantify traffic congestion more precisely than before. This representation was much more precise as each datapoint provided a specific latitude and longitude location rather than solely district and neighborhood names like the population dataset. In order to visualize collision frequency, we plotted a heatmap of vehicles involved w.r.t. latitude and

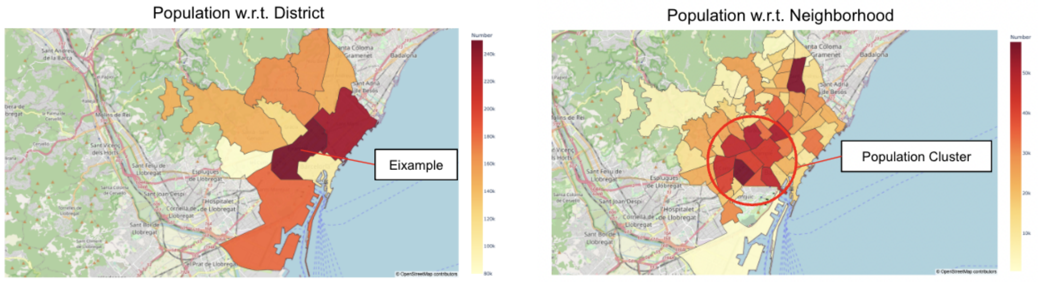

Figure 1: Population visualization of Barcelona w.r.t. district and neighborhood. Population w.r.t. district indicates that Eixample is the district with the greatest average population. With a finer-resolution, population w.r.t. neighborhood supports that there is a population cluster near Eixample.

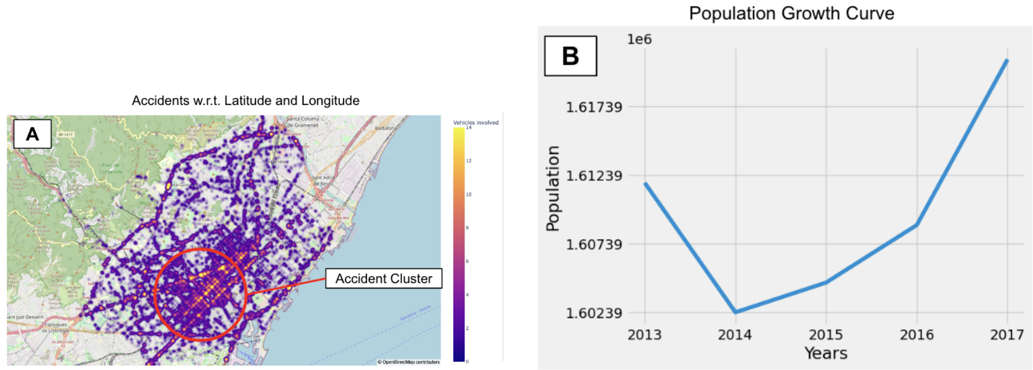

Figure 2: (A). Heatmap visualization with accidents w.r.t. latitude and longitude coordinates. Accidents tend to cluster near Eixample as well, supporting our previous population analysis. (B). Population growth curve from 2013 to 2017. Population in Barcelona is increasing over time.

longitude coordinates to display a relative traffic congestion map. Interestingly, this map supports our previous finding where regions near Eixample would experience the greatest traffic congestion. With a more fine-grained visualization, we quickly noticed a pattern in which roads near the edges of Barcelona tend to have more congestion. Overall, this interpretation supported that traffic congestion was present in numerous areas, however being more concentrated near the Eixample district.

In order to measure the severity of the problem, we examined population growth in Barcelona via a line-plot. From this plot we were able to understand that traffic congestion in the future would only become worse. With a general population growth, the need to address traffic congestion and other population-based issues is becoming more and more critical.

2.2 Air Pollution

The second issue we attempted to address was air pollution in Barcelona. Air quality stations however were in defined regions, making a functional mapping from traffic congestion to quality extremely difficult. However, it is commonly known that all sorts of vehicles emit NO2 and PM10 to some extent. Both of which are hazardous to humans. High levels of

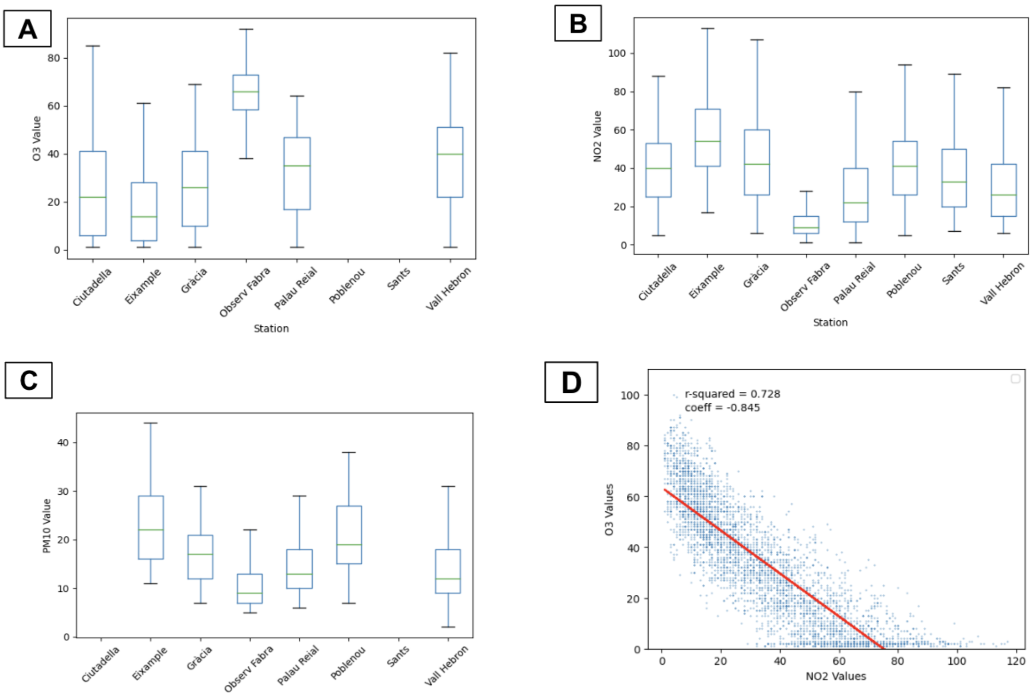

Figure 3: (A, B, C). Boxplots showing pollution values per district with varying pollutants. (D). Regression analysis of NO2 and O3 shows a significant inverse relation.

NO2 have a negative effect on the respiratory system and can cause headaches, nausea, and infections which may have long-term issues [3]. Elevated levels of PM10 can increase the risk of high blood pressure, heart attacks, strokes, and premature mortality [4]. We confirmed that both NO2 and PM10 were more present in areas with higher traffic congestion like Eixample via box plots. However, O3 or ozone did not follow this trend.

In order to investigate this anomaly, we determined a relation between the other known vehicle pollutants, NO2 and PM10, and O3. To test this relation, we performed a regression analysis with each vehicle-emitted pollutant and O3. From our regression plot, we were able to determine a significant inverse relation between NO2 and O3. Previous research has supported this relation between O3 and NO2 [3] It turns out a reduction in O3 results in an increased amount of Ultraviolet radiation reaching the Earth which can lead to skin cancer and impaired immune systems [5].

3 Solution and Implementation Plan

3.1 Overview

From all of this data analysis, we have concluded that the most optimal way to increase Uber's presence in Barcelona is through our "Uber Bus-Kiosk" system.

In our system, we propose that Uber creates a new "Bus-Kiosk" platform which will also be compatible with the Uber app. This platform would provide for an expansion to a new greater market, which will allow for more efficient transportation, while simultaneously

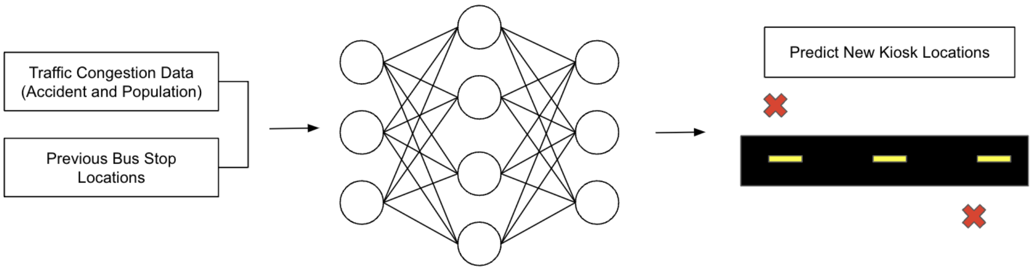

Figure 4: A Flowchart for designing Kiosk placement model.

solving environmental issues. By utilizing buses rather than cars, Uber will be able to be more environmentally sustainable allowing for an overall decrease in traffic congestion and air pollution. This system simultaneously solves the VTC issue which Uber has been experiencing, requiring less drivers. In our Bus-Kiosk system, we would develop'Kiosks in efficient locations, allowing for an interactive interface which would allow for greater client accessibility. These Kiosks would be able to summon a nearby bus which is traveling to a similar destination as the client. These buses would no longer need to stop at unnecessary locations allowing for efficient, and environmentally-friendly transport. This implementation is relatively simple and once finished, widely distributable. This technology could expand to other locations as well, using a predictor to determine Kiosk spots and by implementing a similar path-finding methodology. Once created, this technology can be widely distributed allowing for Uber to work in coordination with local bus companies. In general, our solution provides a robust approach to solving traffic congestion, air pollution and the VTC issue.

3.2 Kiosk

The Uber Kiosk would function as a physical station which complements the Uber app. It will increase the accessibility of our "Uber Bus-Kiosk" system for people with differing technological backgrounds. The Kiosk would resemble an ATM, with a touch screen tablet and a payment system that accepts cash, credit cards, and electronic payments such as Apple Pay, Samsung Pay, and other common payment methods. The user would be able to schedule a bus stop to their specific Kiosk, and a GPS location would be sent to a local Uber bus.

For implementation purposes, we propose creating an AI model to identify optimal Kiosk placements. We suggest approaching this task using supervised learning by training a model on commuter traffic, job traffic, accident probabilities, and air quality as inputs, and previous bus stop locations as a predicted output in order to extrapolate new possible Kiosk placements.

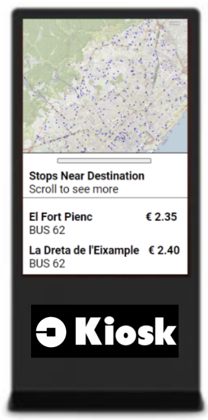

Figure 5: Potential Kiosk design

Figure 6: Plot of 40 randomly selected bus stops in Barcelona. Lines indicate possible destination choices made by users.

3.3 Bus Technology

Buses utilizing our system would require a tablet and a GPS installed. When a Kiosk makes a request, the most optimal bus is chosen. That bus's current navigation system would be automatically rerouted (if even necessary) to efficiently include the new stop into the path. This will allow drivers to maximize the number of riders they get while also serving passengers in areas where buses do not usually go. Each bus would be limited to a certain number of people at a time to preserve the efficiency of the system. By using buses it would reduce traffic congestion and air pollution. With more people taking these efficient buses there would be less individual taxis, reducing traffic congestion. With less vehicles on the road, the effect of vehicle emissions on air quality would decrease. In order to implement this idea, we suggest partnering with local bus companies to decrease the start cost and allow for a distributable system. This implementation strategy would also help mitigate any possible retaliation from citizens against Uber because they would still be using the local bus system.

A new path-finding technology would need to be developed for our buses to work more efficiently. We propose expanding on current navigation systems to have a greater understanding of intermediate stops which can allow for drivers to pick up passengers more efficiently. This has already been implemented by many companies like Apple, however, it is worth testing new approaches.

3.4 Competition

Though our Uber Bus-Kiosk system would be the most advantageous for the citizens of Barcelona, the other transportation systems in Barcelona pose a possible threat to the success of the system. For example, the Barcelona metro system transported over 217.9

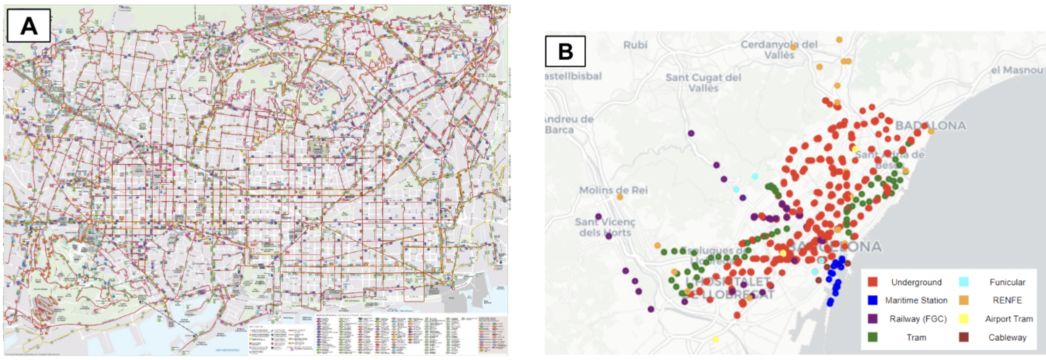

Figure 7: Figure 4: (A). Map of bus system for all bus companies in Barcelona, including stops and routes (B). Geographic plot of every train station in Barcelona.

million people in 2020, compared to the 225.4 thousand people using the bus system [4][6]. When compared to their population, it is plausible then that the average amount of train usage per year is about 135, or every day for a third of the year. Contrarily, this then alludes to the idea that the metro system is less crowded than the bus system, indicating that the bus system is a possibly untapped market.

Another detriment of the current systems is that they have defined routes, including arriving at stops without people. This is forced to happen in the rail based systems like the underground train and the tramway, with their stops shown in Figure 5B, and happens pretty often in the current bus system, as shown in the amount of stops in Figure 5A. This causes unnecessary pollution, uncovered in the previous section, that is killing the planet. This is then very unsatisfying for most users, thus causing them to move away from the public transportation scene entirely. Our Uber Bus-Kiosk system, on the other hand, would allow users to curate their travel plans and decrease the amount of unnecessary driving, thus saving time and saving the planet.

The main detriment of the taxi system in Barcelona is the VTC licensing issue. In Barcelona, taxi companies have to obtain a VTC license for every 30 drivers they have, which can cost from 5,000 euros to 100,000. This is not that financially feasible especially considering that there are not that many taxi drivers in Barcelona. Though the license price is projected to drop, our Uber Bus-Kiosk system avoids the VTC licensing issue entirely; a driver would just need a Type D license to drive a bus, thus saving money and making the field more accessible.

4 Conclusion

To increase Uber's presence in Barcelona, Uber should implement the "Uber Bus-Kiosk" system described above. This system allows for more efficient and environmentally sustainable transport. Traffic, commuter travel times, air pollution, accessibility for the disabled / those in wheelchairs, VTC licensing and the Uber market problem in Barcelona would substantially improve. Our "Uber-Bus Kiosk" system proves superior to previous transport making it an incredibly viable solution for the future.

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