Formula 1 Data Visualization

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1 Introduction

Formula One (F1) is a highly acclaimed and exhilarating open wheeled motor sport known for some of the fastest and technologically advanced racing cars in the world. It is overseen by the Federation Internationale de L'Automobile (FIA) and holds an annual competition for the F1 World Championship by various racing teams around the world. The sport hosts a series of Grand Prix events across the globe, with Singapore being among the host countries, specifically on the Marina Bay Street Circuit - one of the most challenging and unique tracks in the world.

In fact the Singapore Grand Prix is not only an exciting event but also a crucial component of Singapore's tourism industry, attracting a significant number of international and local fans who flock to the Marina Bay Circuit every year. Given the considerable amount of readily available data online, we, as passionate fans of formula one, have decided to undertake an in depth analysis into this sport. Our analysis covers the drivers, teams and an overall comparison of the top players in the sport.

2 Motivation

2.1 Problem statement

With every season and race, there is a vast amount of data that accumulates over time. Unfortunately, this information can be challenging for both new and experienced spectators to acquire and understand. With the abundance of information online, it becomes difficult to identify meaningful patterns and insights that could be leveraged to enhance both driver and team performance. Our goal is to make Formula One more accessible to new fans while also effectively analyzing race data, identifying important performance indicators, and deducing race results using the available datasets.

2.2 Objectives

- To design an all-in-one dashboard that presents our data in a dynamic and user friendly manner, making the data behind formula 1 more accessible and understandable for both new and experienced fans.
- To develop a centralised platform whereby F1 fans can access and examine the sport's data, enabling them to learn insightful things about it and increasing their involvement with F1.
- To develop a platform that will be a useful tool for teams, analysts, and journalists to track performance and make decisions based on the data.

3 Related works

3.1 Total Victory Chart of Drivers

This is an excellent depiction of the top-performing drivers in various races, providing valuable insights into their strengths in different race terrains. However, there is room for improvement in terms of interactivity and filters to facilitate the refinement of results based on specific races and time periods. Furthermore, charts like these are static and can only give a broad overview of drivers' results without giving any insights as to how, when and why they are performing. We can improve the driver comparisons of performance by analysing other aspects such as performance over time and metrics like lap speed, points and pit stop duration. It was uploaded to Kaggle at https://www.kaggle.com/code/jonathanbouchet/f1-data-analysis#drivers-dataset/latex/PMAKEUP.HTM.

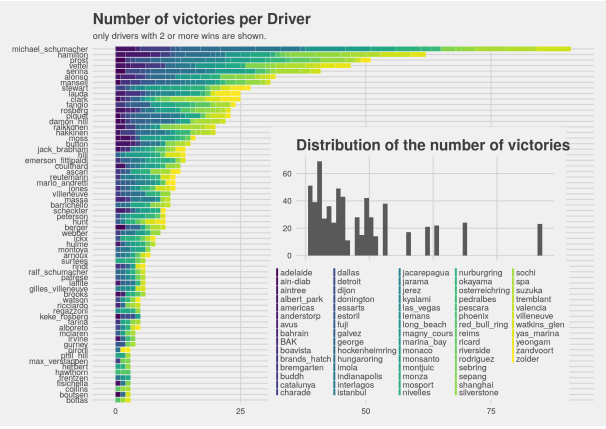

Figure 1: Total Victory Chart of Drivers

3.2 Driver Head-to-Head Comparison

The interactive dashboard offers visualisations that enable users to gain insights and support subjective interpretations by comparing drivers, eras, and technology using different success metrics. It provides informative information for various purposes, such as comparing teams and drivers, tracking technological advancements in the sport, determining the Greatest of All Time, exploring specific drivers' careers, and more (as shown in Figure 2). However, it lacks comprehensive information on other aspects of races, such as terrains, weather conditions, cars, constructors, etc. Moreover, the chart is cluttered with information which is hard to comprehend, especially for people new to F1, when comparing drivers' performance statistics. We can improve this by identifying key driver metrics that matter for F1, and visualising them using comprehensible plots like radar charts and chernoff faces. The dashboard can be found here: https://jasonjpaul.squarespace.com/formula-1-data-vis.

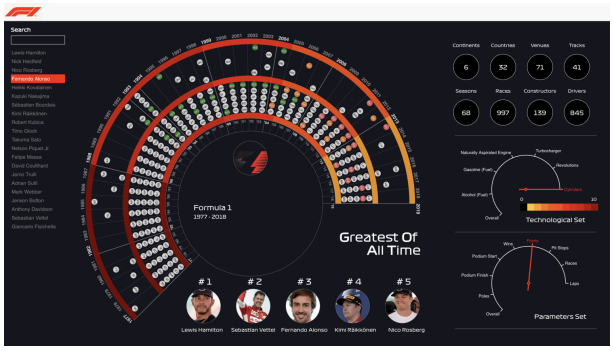

Figure 2: Driver Head-to-Head Illustration

4 Visualisation approach

For the Formula 1 data visualisation approach, we were able to source the required data from Kaggle, a platform that contains a wide variety of big datasets for data analysis. The datasets included information on the Formula 1 races, drivers, constructors, circuits, qualifying, lap times, race results and championships from 1950 to the latest 2023 season. We selected the csv's based on their relevance to our project. After the identification of our purpose and the audience, there were three main steps we followed in our visualisation approach: (i) Data cleaning, preprocessing and preparation, (ii) Exploratory data analysis, (iii) Dashboard Planning and Final Data Visualization.

4.1 Data cleaning, preprocessing and preparation

Basic data cleaning operations were carried out using Excel, including finding and eliminating duplicates, dealing with missing values, and converting data types. In order to group teams' performance by metrics, average pit stop duration, average lap times based on race ID and driver ID, and the maximum fastest lap times for all races for each driver, SQL was utilised for more complex queries. Additionally, it was found that some of the CSV files were missing data from before 2011, which restricted the analysis. As a result, we made the decision to limit our research to only the years that followed 2011.

4.2 Exploratory data analysis

In order to gain a general grasp of the dataset after the data preprocessing, our first step was to explore the data. For the analysis, we selected key indicators and dimensions such as race results, driver and team rankings, lap timings, race location, and race date. After this, we performed basic univariate analysis on each metric individually using visualisations such as box plots and histograms to identify general trends since there was so much information.

4.3 Dashboard Planning and Final Data Visualization

For this project, we utilised a variety of resources to create a comprehensive and effective dashboard. Our primary tools for data visualisation were Tableau and R, with the latter being used specifically for creating unique visualisations such as chernoff and radar charts. The initial ideation process involved brainstorming and sketching out ideas, followed by identifying the key metrics and KPIs to be tracked. We then defined the overall dashboard structure and layout based on our findings. To create engaging and informative visualisations, we utilised Tableau's powerful data visualisation capabilities, as well as R packages for chernoff and radar charts. These visualisations were

particularly effective in highlighting specific data points and comparing them to a reference point, such as Lewis Hamilton in the case of the radar charts. Additionally, chernoff faces were used to visually represent multiple variables on a single chart. Overall, the combination of these resources allowed us to create a visually appealing and informative dashboard that effectively conveyed our data insights.

5 Data Visualisation Walkthrough

The 4 main dashboards available in our visualisation are outlined below:

5.1 Homepage

The homepage provides a concise and informative overview of the F1 races spanning from 2011 to the present day, featuring race-related details such as the champions, driver lineups, and race information for each year. In addition, the dashboard displays the history of the teams that competed in previous years, as well as the seasonal point progression of a selected driver, making it a comprehensive and valuable resource for fans and enthusiasts of the sport.

Figure 3: Homepage

5.1.1 Race Information

Within this section, you'll find two visuals: a map and a bubble chart. The dynamic map showcases the locations of each race, with the size of each point reflecting the number of races that occurred in that area. The engaging bubble chart offers a compelling illustration of track popularity and their associated countries.

5.1.2 Champions

The champions section comprises two components: the drivers and the constructors, with each chart offering an insightful look into their accomplishments. The bar chart showcases the number of wins accumulated by each player, with the teams represented by distinct colours and the circuits identifiable by hovering over each bar. Additionally, the pie chart located at the bottom of the chart provides a clear snapshot of the driver who claimed the championship for that particular season.

5.1.3 Constructor

Similarly, the constructor section also boasts a powerful bar chart, depicting the number of wins achieved by each team, with the drivers represented by colour-coding and the circuits again identifiable by hovering over each bar. The pie chart located at the bottom of the chart offers an indication of the team who emerged victorious as the champions of that season.

5.1.4 Driver Lineup

The driver lineup is displayed in a table format, providing a comprehensive overview of both the driver and the corresponding constructor.

5.1.5 History

The team history is presented in a Gantt view, with each year colour-coded to reflect the corresponding constructors that participated.

5.1.6 Seasonal Point Progression

This insightful line chart illustrates the progression of the selected driver's performance throughout the racing season, showcasing the number of points accumulated for each round.

5.2 Driver

The driver dashboard provides various comparison charts that allow dashboard users to filter and search for drivers by name, year of the race, and race name from 2011 onwards. The dashboard provides a comprehensive overview of driver performance over the years, comparing them to other drivers in terms of accumulated points, as seen in Figure 4 .

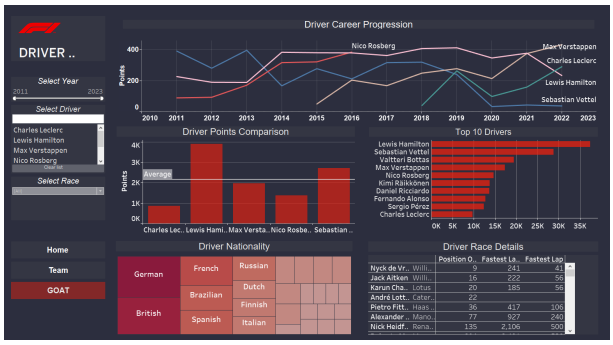

Figure 4: Driver Dashboard

5.2.1 Career Progression

The line chart allows to track the accumulated point gains in a year by the drivers over the year based on selected year(s) and selected driver(s). The line chart allows users to understand how consistent the drivers are accumulating points over the year.

5.2.2 Driver Points Comparison

The bar graph chart allows to compare accumulated points gain of drivers over the course of a year, based on selected year(s) and selected driver(s). The average reference line is calculated based on selected race, year, race name. By analyzing the graph, users can gain insight into how different drivers accumulate points over time, and whether certain drivers have gained more points than the average among the selected drivers.

5.2.3 Top 10 Drivers

The bar graph gives us an overview of the top 10 F1 drivers accumulated points sorted in descending order from 2011 onwards and we make use of calculated field to get top 10 drivers based on race result points.

5.2.4 Driver Nationality

Treemap of drivers' nationality who have participated in the year, with both size and colour based on count of drivers of every nationality. Users can filter by a specific year or range of years.

5.2.5 Driver Race Details

The driver details are displayed in a concise table, showing the driver's name, his team, his position in the race, his fastest lap speed and his fastest lap timing based on users' driver input.

5.3 Teams

The team dashboard provides the various charts and metrics in which one can use to compare team performances. Some of these charts can be filtered by teams, years and/or performance metrics. The performance metrics are "SUM(Points)", "SUM(Laps)", "Fastest Lap Speed" and "Avg Lap Speed".

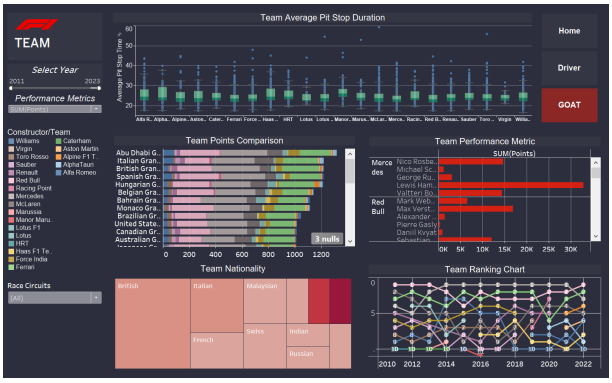

Figure 5: Main Overview of Team Dashboard

5.3.1 Team Nationality

This is a treemap of F1 teams by nationality, with size based on number of teams and colour based on number of race wins. Users can filter by "Year" to identify the common or major performing regions for F1 in a certain year.

5.3.2 Team Ranking Chart

A Bump Chart that shows the rank of teams who participated in F1 races over the years from 2011 to 2022. They are ranked via their aggregated points within a year. Overall, users can easily identify and compare team performances.

5.3.3 Team Performance Metric

Categorises the drivers by teams and illustrates the make-up of performance metrics in the team. Users can filter by "Year" and "Nationality" and "Performance Metric". This allows for clear recognition of highest performing drivers by teams, which can be used to analyse

drivers' and teams' areas of improvement.

5.3.4 Team Points Comparison

This is a stacked bar chart which displays the breakdown of points for each type of race circuit, for example Abu Dhabi Grand Prix, stacked by the teams who participated in the race and their points accumulated. Since every race track is different in their length, corners, visibility and surface, this would let users find out the type of race circuits F1 teams are good and bad at. Some uses of such charts are that users can approximate win percentage on a certain race circuit, or they could try to identify circuits they are not good at and improve their training programmes.

5.3.5 Team Average Pit Stop Duration

Box-and-whiskers chart that illustrates the average pit stop duration for every team in a year. The chart shows the time spent in seconds for each team on pit stops, allowing for comparisons of time spent as well as variability of such duration among teams. Users can filter this chart by "Year".

5.4 Greatest Of All Time Dashboard

The goal of the GOAT comparison dashboard was to identify the key metrics and visualisations that would make it possible to compare the greatest Formula 1 drivers of all time in a comprehensive and useful manner. Below we have outlined the dashboards three main features as well as the key metrics that formed the basis of our visualisations. Fans, new viewers , and analysts who want to learn more about the sport and its top players will find the dashboard to be a useful tool.

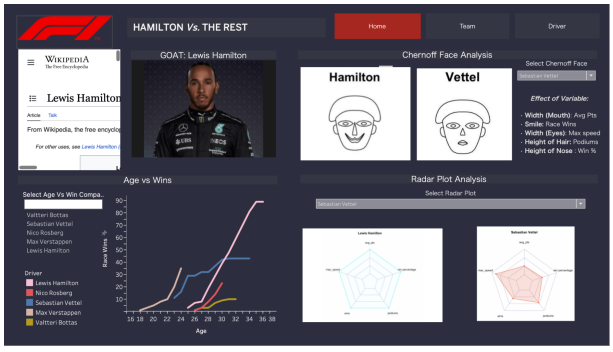

Figure 6: Main Overview of GOAT Dashboard

5.4.1 Key metrics

In our analysis we identified 5 key metrics to compare the drivers that we thought were very insightful. These metrics included the total race wins of each driver from 2011- 2023, the corresponding race win percentage, the number of podium wins, the drivers max speed and the average points won by each driver over the span of all their races. These criteria were chosen because they are important in assessing driver performance and because they can be used to compare all of the top drivers in the sport across a range of strengths. The dashboard includes three main visualisations to facilitate the comparison of the drivers:

5.4.2 Age vs Race Wins

This visualisation plots the age of the driver against the number of race wins. It is a useful method for assessing the driver's performance over time and offers perspective on their career path. It can reveal, for instance, whether a driver's performance peaked quickly or was able to be sustained for a longer amount of time.

5.4.3 Chernoff Faces

We were able to utilise the aplpack package available in R to plot the necessary Chernoff faces. Chernoff faces are a form of scatter plot that employ facial traits to represent numerous variables on a single chart. Each feature (such as the shape of the lips or the size of the nose) is mapped to a different variable, making it possible to show high-dimensional data in a straightforward and condensed manner. In our dashboard, we used Chernoff faces to compare various attributes of the drivers as outlined in our key metrics.

5.4.4 Radar Charts

In order to create our star plots, also known as radar charts, we used the package fmsb in R. Radar charts are a useful tool for comparing multiple variables across a group of items, especially when the variables are equally significant and have comparable ranges of values. In our dashboard, we utilised radar charts to compare the performance of other drivers to Lewis Hamilton, the best performer. Hamilton was used as a benchmark to help us understand the elements that go into Formula 1 success and to shed light on the drivers' strengths and limitations in comparison to his performance.

6 Key Findings and Observations

6.1 Driver Findings

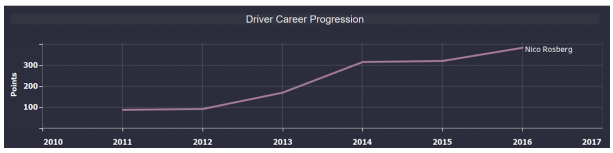

Figure 7: The line graph represent the points accumulated over the years

When analysing the accumulated points gained by Nico Rosberg, we could see the constant positive upwards trends for points accumulated .The most accumulated points in the year for Rico would be in 2016 which is the year he left F1 during the peak of his career as seen in Figure 7.

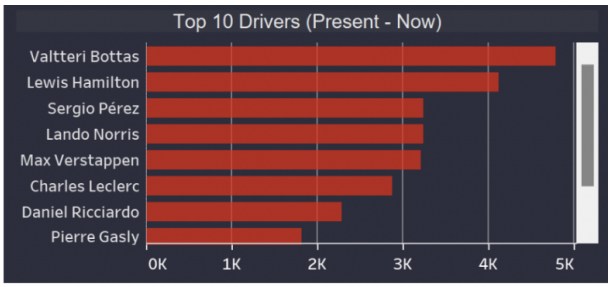

Figure 8: The bar graph represents the top 10 drivers based accumulated points from 2020-2021

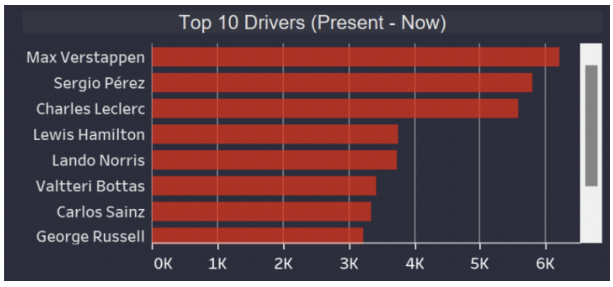

Figure 9: The bar graph represents the top 10 drivers based accumulated points from 2021-2022

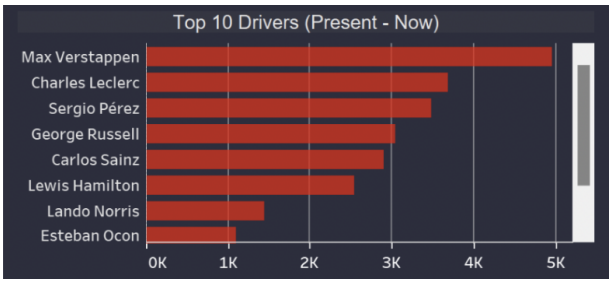

Figure 10: The bar graph represents the top 10 drivers based accumulated points from 2022-2023

Based on the last 3 years of race from 2020-2022, Max Verstappen has remained as the top 5 drivers based on accumulated points. Max Verstappen has rose from the 5th rank to 1st rank constantly for 2 years as seen from Fig 8-10. It is likely if Max constantly gains the same points in the next 5 years as he is in his 20s, it is likely that he will replace Lewis Hamilton as the next goat. It is worth mentioning that Max started his career in 2015 and has radically increased his points accumulated.

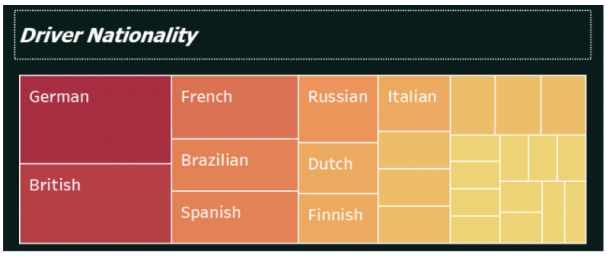

Figure 11: The tree map colour represents the number of nationality of the drivers

As observed in the treemap, drivers that took part in the F1 races are from European countries. As supported in figure 11, we could observe that the larger rectangles are from European countries generally.

As observed in the line chart in Fig 12., we can see that Lewis Hamilton and Max Verstappen are the only drivers who have accumulated more than 400 points in a year, making Max an outstanding driver. He has achieved the highest number of points in a year as of 2011, surpassing Lewis, which is impressive.

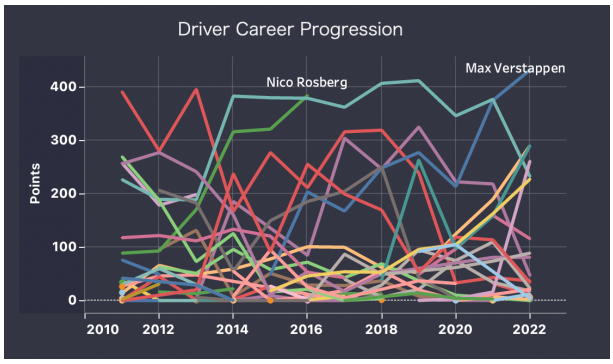

Figure 12: Line Chart representing the points accumulated by different drivers that took part in the race from 2011-2023

6.2 Team Findings

Looking at the treemap of the team nationality, we can see that most F1 teams are from European regions, especially from Britain and Italy. However, the most skilled teams are actually from Germany and Austria.

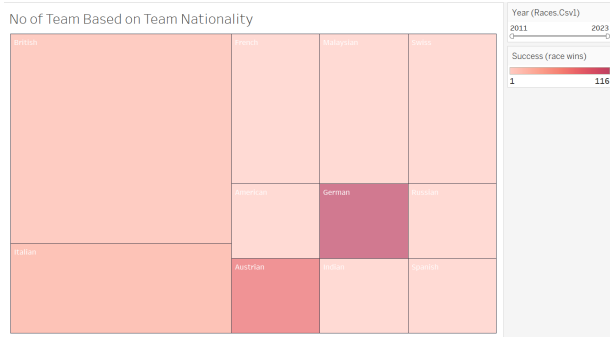

Figure 13: Team Nationality(2011 - 2023), size based on number of teams and colour based on number of wins

As shown in Figure 14, Team performances vary over time as seen from the change in ranks, especially for the bottom half of the rankings (5-10). However, we can identify the 3 teams who are the most consistently competitive teams as they regularly rank among the top 3 over the years. These 3 teams are Mercedes, Red Bull and Ferrari. This could be due to the team's technological prowess such as car technology, the driver's racing capability, or a mix of both. In particular, Mercedes has been dominating the first rank for many years recently, but have conceded that rank to Red Bull in the most recent year 2022, which could be a point of analysis on what has happened.

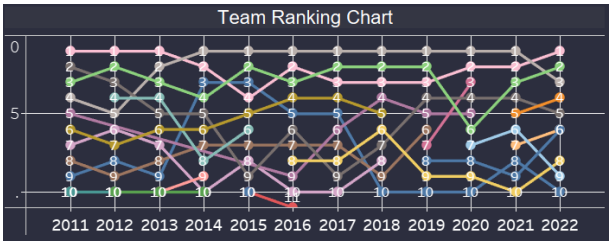

Figure 14: Team Ranking Bump Chart colour-coded by team from year 2011 to 2022

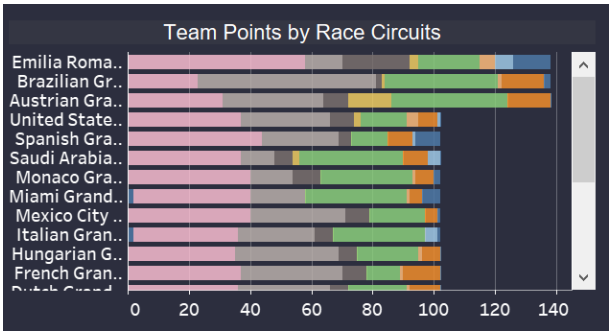

Figure 15: Stacked bar chart of accumulated points of every team across the different race circuits for the year 2022

From this stacked bar chart in Figure 15, users can identify the teams who are likely to do well for a specific race circuit. For example Abu Dhabi Grand Prix, we can observe that Mercedes tend to do the best, followed by Red Bull and then Ferrari. Users can filter for a specific year to analyse all teams' performance for that year's race circuits.

Filtering for the year 2022, we observe that there are race circuits where Mercedes has significantly lesser points than Red Bull, such as in Emilia Romagna Grand Prix, Saudi Arabia Grand Prix and Monaco Grand Prix to name a few. Comparing Mercedes' points in 2021 and 2022, Mercedes has generally worse performances in certain race circuits compared to their competition. From

the year 2021 to 2022, Mercedes' points obtained in the British Grand Prix decreased from 43 to 16, and decreased from 41 to 11 points for the Saudi Arabia Grand Prix.

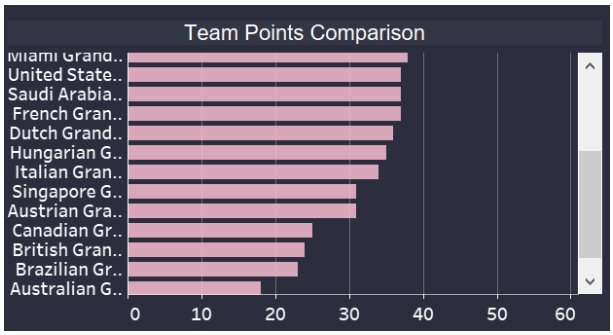

Figure 16: Team points comparison filtered by team Red Bull for year 2022

If we are interested in Red Bull in the year 2022, we can filter accordingly and observe that they do not seem to perform well for the Australian, Brazilian, British and Canadian Grand Prix. Looking at the Australian Grand Prix, this could indicate certain weaknesses of the drivers at the race circuit. The track layout includes a mix of high-speed corners and chicanes, which require drivers to have a high level of skill and precision to navigate at high speeds. Additionally, the race is also held in Melbourne known for its changeable weather, where drivers have to adjust driving style and strategy on the fly. These could be flaws of Red Bull drivers, and the team can use this information to improve their training programmes to overcome these issues.

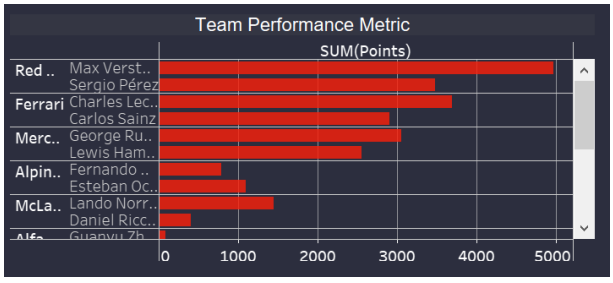

Figure 17: Performance Metrics for Drivers and Teams for the year 2022

From the Team Ranking Chart, we saw that Red Bull passed Mercedes in the ranking. Using Figure 17, we look at the point breakdown in Red Bull. While both players are good and earn many points for the team, Max Verstappen earned much more points than his peer, which could signify his growing ability as an F1 driver.

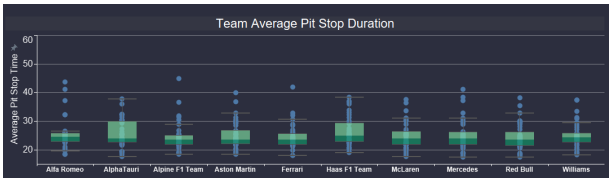

Figure 18: Team Average Pit Stop Duration in seconds for the year 2022, with red line as a ruler to compare outliers for Ferrari, Mercedes and Red Bull

As the pit stop durations chart for all the years contains white noise and is hard to analyse, we filter for the year 2022. Inspecting Figure 18, we noticed that the other top teams (Mercedes and Ferrari) have a greater spread of average pit stop duration than Red Bull, particularly their outliers at the top are greater than Red Bull. Max Verstappen might not only be the reason why Red Bull is doing better in the year 2022. This means that the other teams would have to reconsider their pit stop strategies, such as balancing the pros and cons of getting new tires versus continuing on ones that have been worn down already at different race circuits, in order to optimise pit stop durations so that they can gain a lead or level the playing field.

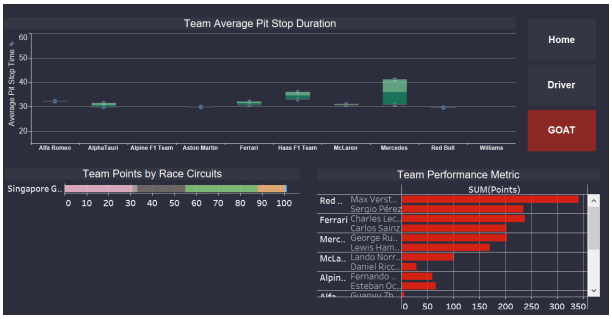

Figure 19: Filtering Team Dashboard for Singapore Grand Prix in 2022 for the 3 performance sheets as shown

We can analyse their performance based on the Singa-

pore Grand Prix as well, which is a race circuit which Mercedes is not doing well too. If we compare Mercedes and Red Bull, the average pit stop duration for Mercedes is higher than Red Bull, which could indicate team issues which led to lesser points earned for this race. Mercedes should aim to minimise their pit stop duration to be competitive with the other teams, in order to obtain a higher ranking in the future.

6.3 Greatest Of All Time (GOAT) Findings

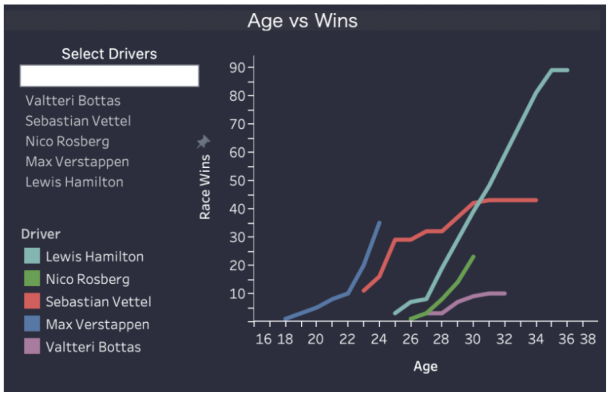

Figure 20: Age vs Win chart showing the GOAT Hamilton and the next 4 most successful drivers in the last decade

The line graph represents the relationship between age and race wins. For simplicity, top 5 drivers based points since 2011 have been selected to represent the correlation between age and race wins. As seen above, as the driver ages the number of race wins starts to slowly increase, gains momentum and starts to slow down eventually. Bottas and Vettel, significantly deteriorated in their winning ability in their early-30's and have not been able to recover since. Hamilton's wins multiply between the ages of 27 and 35, and after that they stagnate abruptly. This can be explained by the massive regulation changes in F1 that took place 2 years ago that saw the Lewis's Team - Mercedes no longer a front-runner. This reveals the importance of the team in a driver's career. Max Verstappen, on the other hand is on an exponentially increasing path at a startlingly young age (his line lies above everyone else's, and also starts before anyone else's).

Apart from further emphasising Hamilton's competitive advantage over his peers in all 5 metrics, the radar plot analysis also shows that the maximum speed achieved by all drivers is not a large differentiating factor. Thus this shows that, to be successful in F1, there are many more important things having the fastest speed. The other four drivers had different competitive advantages - Rosberg had a high win percentage, Vettel had a high podium count, and Max Verstappen scored a high average points per race. Thus, the recipe to success is not one-size-fits-all, and people have unique strengths.

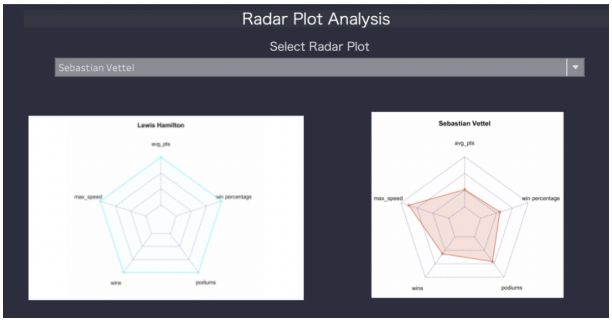

Figure 21: Radar Plot

The Chernoff faces analysis primarily serves as an accessible way for non-statisticians or people familiar with numbers and data to gauge how successful a driver is. We set the metrics in such a way, so as to allow a happier, smiling and wide-eyed face to represent more success. The inferences from this visualisation matched those of the radar plots.

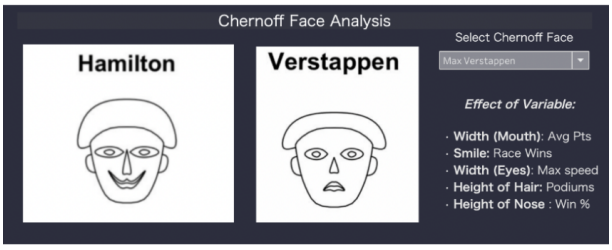

Figure 22: Chernoff Faces

7 Limitations

7.1 Home Performance challenge

We faced a significant challenge in constructing the homepage - determining which content should feature prominently without encroaching on other dashboards or overwhelming the user. Our ultimate decision was to showcase general information such as race locations and tracks, alongside a concise summary of F1 champions throughout the years. This approach not only provided users with a glimpse of the world of F1, but also allowed them to dive deeper into drivers, teams, and race strategies using the subsequent dashboards.

7.2 Driver Performance Challenges

One of the challenges faced in constructing driver performance is by understanding the performance metrics to determine the top 10 drivers and make comparisons between drivers. Initially, we explored wins from the driver standing table. However, it was not a good way to represent driver performance as we could not see the scale of difference between drivers, as most drivers had zero wins. We explored points from the result table as it is a fair judgement, as it accumulated points gained by every driver in a race from the start of the analysis period.

7.3 Team Performance Challenges

Some of the challenges faced in constructing the team performance : (1) ensure it doesn't overlap with the driver's dashboard to cope with it so we constantly keep each other informed of what we intend to do (2) understanding how can we leverages on the drivers dataset and group them by the constructors as we think it is not intuitive to not include the drivers of that constructors .To cope with it , we incorporate with the result.csv to help us to link to drivers dataset to measure the different performance metrics (3) Planning on how can we allow use the same sheet to represent the performance metrics of "SUM(Points)", "SUM(Laps)", "Fastest Lap Speed" and "Avg Lap Speed" in the same sheet as one of the example on handling complex aggregate data is by handling more than one fastest lap speed in result.csv for each driver and race, hence we decided to use SQL to handle to calculate the max fastest lap speed among all races taken by the driver (4) understanding how can we representing the team ranks over the year without overcomplicated things to cope with it, we recalled labs on the ranking and decided to implement the method into team performance.

7.4 GOAT Analysis Challenges

Our challenges for this dashboard stemmed from 2 main sources. The first was the limitation of Tableau in terms of visualising high-dimensional data. The available tools and graphs were limiting for our desired outcome, as we wanted to conduct more sophisticated and unique visualisations such as Chernoff faces and Radar Plots. Second, it was a challenge to choose the specific metrics and the number of metrics to include in our analysis. We spent considerable time researching the various strengths of a driver in F1, and melded these to match the datasets we had. The solution to our two challenges was to use R which proved a powerful tool - not only to generate the chernoff and radar plot visualisation but also to wrangle and mutate the data to feed these charts.

8 Conclusion future work

8.1 Conclusion

In sum, this project not only utilised a wide range of data - from driver profiles, to pit-stop times of races, and even relative individual strengths of teams and drivers; it also incorporated depth in terms of time trends, forecasting, and comprehensive analysis for each individual stakeholder. We were able to take advantage of our vast dataset, as well as the natural ranking characteristic of the sport (everything is judged on speed, wins, or championships), and produce unique visualisations that gave further insight into the progress, success or failure of a driver or a team. Each dashboard individually conveys an in-depth comparison across various parameters, but when a user travels through the dashboard starting from the homepage which gives a glimpse of an F1 season, through to the driver dashboard which provides understanding of the main players of F1, and then to the Team dashboard which colours the background and more hidden aspect of the sport, and finally to the GOAT dashboard which shows how all the factors come together to produce these racing legends. We were able to derive various interesting inferences that mainly fell into two categories: either they were an explanation to an observable fact (e.g. Teams

success is partially attributed to its consistency in fast pit-stop times), or they were forecasts based on trends (e.g. Max Verstappen's accelerating trajectory to become more successful than the current GOAT - Lewis Hamilton).

8.2 Future Work

As our dashboards are mainly descriptive visual representations based on the past race results since 2011, factors such as weather conditions, track conditions, and technology, such as engine technology, are not included. Here are some future considerations:

1. Predictive Race Strategy Analysis: To increase the success rate of constructors, one of the key performance metrics to consider would be the winning rate of the drivers within a constructor to calculate the likelihood of their chances of winning in the next race.

2. Does years of experience help with race performance? Consideration of calculating the years of experience of the drivers versus the number of wins by the drivers would help to draw a comparison of whether years of experience affect the performance of the races or the chances of winning.

3. Does weather and race track condition affect race performance? To understand if weather and race track conditions affect race performance, we could use the milliseconds from the result.csv to make a side-by-side comparison of the same driver's performance based on these factors.

4. Does engine technology affect lap timing? Hybrid engine technology allows the car to be more powerful and efficient in fuel consumption, which can significantly affect the performance of F1 races. The use of hybrid engines allows for faster lap times while consuming less fuel. To understand this relationship, we could analyze the performance of a driver driving different vehicles with one using older engine technology and another using newer technology to compare the lap time performance.

9 References

[1] Bouchet, J. (2017, December 09). F1 data analysis. Retrieved March 3, 2023, from https://www.kaggle.com/code/jonathanbouchet/f1-data-analysisdrivers-dataset

[2] Dey, V. (2022, June 10). Why are F1 teams turning to Big Data Analytics? Retrieved March 3, 2023, from https://datatechvibe.com/data/why-are-f1-teams-turning-to-big-data-analytics/

[3] F1 - the official home of Formula 1® racing. Formula 1® - The Official F1® Website. (n.d.). Retrieved April 7, 2023, from https://www.formula1.com/

[4] G, C. (2017, November 28). Formula 1 race data. Retrieved March 3, 2023, from https://www.kaggle.com/datasets/cjgdev/formula-1-race-data-19502017

[5] Jonbown. (2023, April 3). formula 1 post-race summary . Kaggle. Retrieved April 7, 2023, from https://www.kaggle.com/code/jonbown/formula-1-post-race-summary

[6] Lyons, B. (2018, November 6). 8 ways to bring powerful new comparisons to viz audiences with tableau set actions. Tableau. Retrieved April 7, 2023, from https://www.tableau.com/blog/8-ways-bring-powerful-new-comparisons-viz-audiences-set-actions-97207

[7] Mitchell, S. (2022, August 10). Data Analytics: Managing F1's Digital Gold. Retrieved March 3, 2023, from https://www.racecar-engineering.com/articles/data-analytics-managing-f1s-digital-gold/

[8] Paul, J. (n.d.). F1 data visualization. Retrieved March 3, 2023, from https://jasonjpaul.squarespace.com/formula-1-data-vis

[9] ToUpperCase78. (n.d.). Datasets and Analyses for Formula 1 world championship. Retrieved March 3, 2023, from https://github.com/toUpperCase78/formula1-datasets

[10] Vopani. (2023, February 18). Formula 1 World Championship (1950 - 2023). Retrieved March 3, 2023, from https://www.kaggle.com/datasets/rohanrao/formula-1-world-championship-1950-2020