CISA Student Showcase

Using Python and Fast F1 to Pull and Analyze Data on Tire Degradation in a Formula 1 Grand Prix

Elena Mugge and Dr. Michelle Zandieh

Introduction

Background

The performance of a driver in a Formula 1 Grand Prix is heavily reliant on a Race Strategy Engineer in the garage creating the race plan and relaying information to the driver during the race. A good strategy can make a race as much as misinformed strategy can ruin one, and tire strategy is extremely important and different every weekend based on changing variables.

- Three levels of tire are supplied to the teams for use in a grand prix weekend. The different tire 'compounds' are Soft, Medium, and Hard and are made up of varying levels of rubber, carbon, and oil. The tires each perform slightly differently when it comes to speed and degradation.
- Tire degradation is a result of the friction caused by downforce, heat, pace, etc. Each tire has an optimal window lap life of how long the tire can be driven on until the tire loses too much to degradation and becomes slippery and undrivable.
- A softer will warm up the quickest and achieve the fastest lap times, but soft tires will degrade quickly and need replacing every couple of laps. The softest compound is used during Qualifying when the fastest single lap sets the starting race grid. Harder tires have slower degradation and can go longer between pitstops. Any arrangement of the three can be used in the race, but to avoid time lost in extra pit stops, typically Medium and Hard are the chosen compounds.

Research Question

How can the data from a Formula 1 Grand Prix weekend be pulled from the FastF1 database using Python and analyzed to predict and create the optimal race plan when considering pit stop and tire strategies?

Analyzing free practice data for lap times in reference to the specific tire, fuel levels, track temperature, and tire stint lengths, and cross-referencing lap times and tire stint lengths with live race data during the race in terms of the same variables as well as estimated pit stop time and track position, an informed strategy for tire compounds and pit stops can be produced and adapted to predict the strategy that will result in the least tire degradation and quickest pace to optimize track position

Critical Methods and Functions to analyze data that is accurate and helpful:

- In order to pull data for a race, session, and driver, the functions fast.f1.get_session('year','race','session) and session.laps.pick_driver('XXX') are used to specify the exact data needed and order it by laps in the chosen session.
- 'session.load(laps = True, weather = True)' pulls only the data stored under laps and weather and prevents the code from having to sort through the entire system of data stored in Fast.F1 and allows the lap data and weather data to be accessed through a function like get_weather_data('TrackTemp', 'WindSpeed') to display the exact conditions needed to analyze the weather's affect on tire degradation
- 'quicklap_threshold' and 'pick_quicklaps([threshold])' allows you to specify and pull only the laps with times under a designated 'threshold' in order to weed out outliers like laps coming into the pit or laps with times that aren't accurate in predicting race performance from Free Practice laps.

```
session = fastf1.get_session(2023, 'Italian Grand Prix', 'R')
session.load(laps = True)
th = 1.1
leclerc = session.laps.pick_drivers("LEC").pick_quicklaps(th).reset_index()
print(leclerc[['Driver','LapNumber','LapTime','Compound','TyreLife']])
```

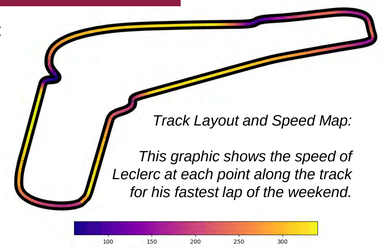
This is an example of the specifications used to only pull Leclerc's data from the feature race of the Italian Grand Prix, and exclude any lap time over 110% of his fastest time to avoid outliers. This prints the lap number with its duration for every lap that did not have its time effected by pitting for new tires, along with the compound and age in laps traveled of the tires through the race.

ASU College of Integrative Sciences and Arts
Arizona State University

Understanding the Data and its Use in Strategical Analysis in a Grand Prix

Background information for the data I chose to analyze:
Event: 2023 Italian Grand Prix
Driver(Team): Charles Leclerc (Scuderia Ferrari)
Track: Monza
Location: Monza, Italy
Drivers: 20 (10 teams)
Weekend's Sessions:
- Fri: Free Practice 1 & 2
- Sat: FP3, Qualifying
- Sun: Feature Race

Feature Race Specs:
- Lap Length: 5.793 km
- Total Laps: 53
- Track Temp: 40.8 to 44.4 C
- LEC starting pos: 3rd
- LEC ending pos: 4th



Track Layout and Speed Map:

This graphic shows the speed of Leclerc at each point along the track for his fastest lap of the weekend.

Fastest lap time and highest life of tire for each tire compound:
Leclerc – 2023 Italian Grand Prix Weekend
One lap qualifying pace is shown for each tires when pushing for the fastest possible lap and not conserving tire life in terms of degradation with very low fuel weight, unlike race pace which is 4-6 seconds slower for this gp.

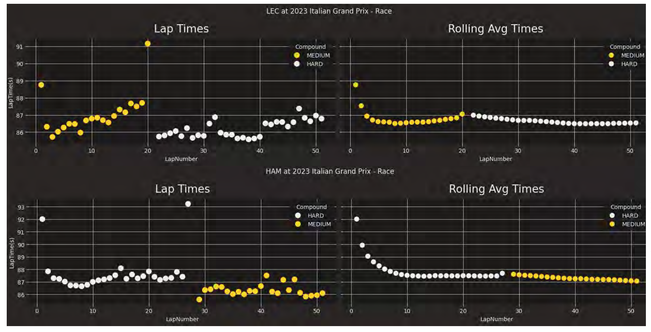
Compound	SOFT	MEDIUM	HARD
LapTime	00:01:20.361000	00:01:20.977000	00:01:21.788000
TyreLife	9.0	20.0	32.0

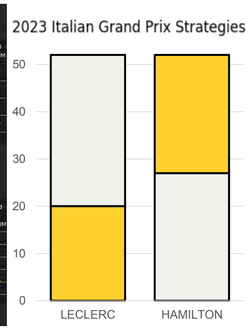
Example of opposite tire strategies:

Charles Leclerc's team opted to start on mediums and switch to hard on lap 20 while Lewis Hamilton started on hards and switched to medium on lap 28.

- A medium tire in the beginning gives a driver more speed in the first lap to overtake when the field is condensed. An earlier pit stop also provides the driver with warm tires compared to the cold fresh tires of the opponent when they pit second.
- Starting with the harder tire delays the pitstop while gaining track positions as the field in front pits, and then finishing on the significantly quicker to focus on overtakes at the end of the race.

	Driver	Stint	Compound	StintLength
0	LEC	1.0	MEDIUM	20
1	LEC	2.0	HARD	32
2	HAM	1.0	HARD	27
3	HAM	2.0	MEDIUM	25



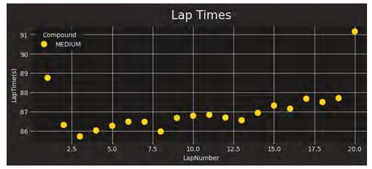


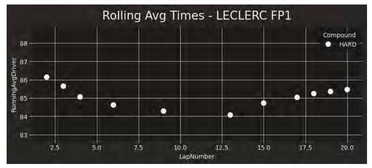
By pulling the data for the lap times and computing for the rolling average of both Leclerc and Hamilton in the Feature Race, we can see evidence of how the fuel load affects the two strategies. Leclerc started the race on medium. The car is heavy with a full load of fuel leading to higher degradation, but quicker laps compared to Hamilton doing slower laps on the hard. In the latter laps of the race the fuel load is lighter and quicker with less degradation, Leclerc on hards was able to use the minimal degradation to stretch the second stint and keep relatively consistent lap times to stint 1. Hamilton on the medium tire had similar length stints, but quicker laps on the 2nd stint. However, the rolling averages show that the resulting lap average for Leclerc finishing in 4th was 01:26:53 and for Hamilton 31 seconds behind in 6th with an average lap of 01:27:06

Analyzing Past and Live Data for Strategy During a Race

Before a race, a strategy is developed for the order of tires and for the amount and timing of Pit Stops. Live race data, such as the current tire degradation or a driver's on track position compared to the opponents, affects the tire and Pit Stop strategy and can completely change from what a Race Strategist had predicted based on Free Practices (FP) and data from past races.

In this particular Grand Prix, the pit stop window for someone who started on medium tires was expected to be between laps 20 and 26. When looking at the tire life and stints, Leclerc's team made the decision to switch to hard tires on lap 20 while having confidence that the new hard tire would last the remainder of the race.





Driver	LapTime	Compound	TyreLife
LEC 0 days	00:01:26.864000	HARD	18.0
LEC 0 days	00:01:26.377000	HARD	19.0
LEC 0 days	00:01:26.525000	HARD	20.0

Live data from Stint 1 of the race shows:

- Medium tire's optimal pace window in laps 3-8 show an average optimal lap time of 01:26.148.
- Laps 13-19 average pace is 01:27.38, over a second slower than the optimal pace average.

Free Practice 1 Hard Tire data shows:

- With 3/5 of the race left, the amount of gas in the tank will also be around 30-40% lighter leading to less tire degradation and quicker laps.
- As shown in the data to the left, Free Practice 1 lap times and Rolling data shows that the tire life at lap 20 is around the 01:26.50 mark, with similar fuel usage to the Medium tire with slower times on the same number of laps driven.
- Pirelli pre-race tire statistics state that a medium tire lasts 75% of the distance a hard tire would last in the same conditions. The hard should perform as good or better over the next 30 laps compared to the medium after 20 laps.

Conclusion:

By considering the given factors as well as monitoring variables such as wind speed and track temperatures, the Race Engineers could be confident that the medium tire was slowing the car down substantially by lap 20, and that a hard tire would be able to last the remaining 30 laps with less degradation at the end of the race than the medium was currently showing, as well as being able to achieve quicker laps than expected from FP1 due to less fuel weight in the second stint.

Through understanding the impact certain variables will have on race pace, models and charts can be created through Python by pulling specific and accurate information from the entire database of every session past and present. This reduces the chance of human mathematical error, increases prediction accuracy backed by a larger data pool, and allows tire strategy to be analyzed and updated on a moments notice as live data is gathered during the race.

This shows a brief example of how strategy for a grand prix is formed by analyzing variables such as tire compound, fuel weight, and weather to predict with the highest accuracy, their effect on tire degradation and lap times over the entire grand prix. By analyzing how the different variables effect the overall speed of the car and tire life, a Race Strategy Engineer can create a tire strategy that optimizes tire compounds and pit stops for the best overall race pace.

References

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