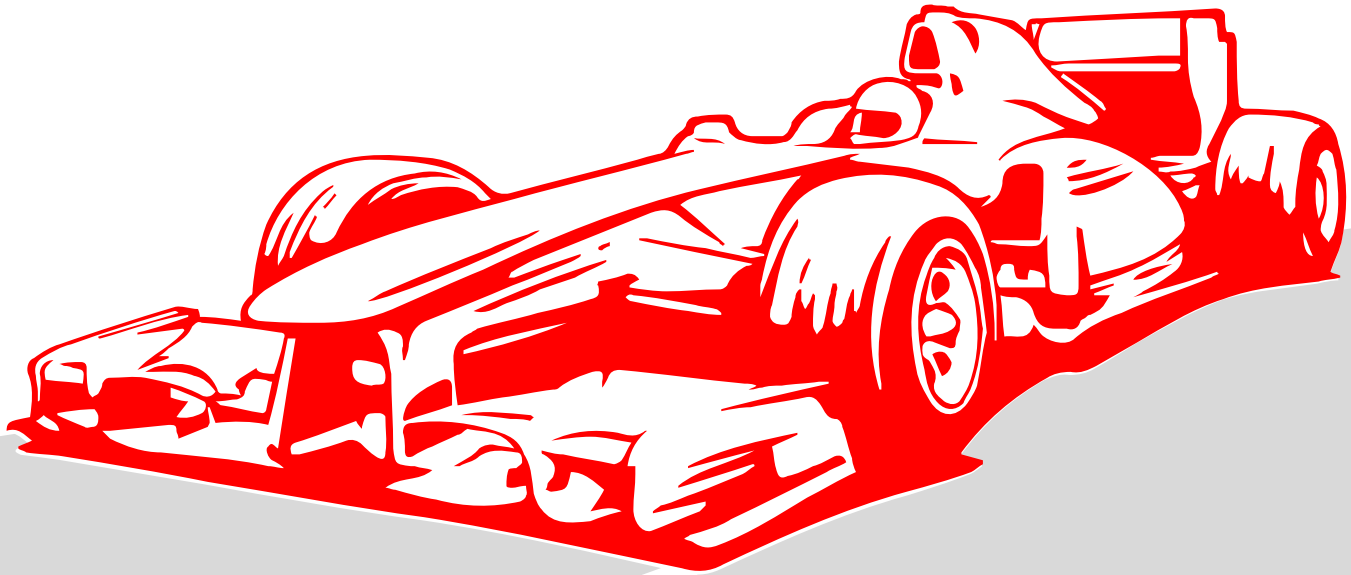
F1 Data Analysis

Load Transfer Estimation

F1 Data Analysis
@F1DataAnalysis



1 | Introduction

2 | Computing the Longitudinal Acceleration

3 | Estimating the Tyre Load

4 | Changing the Car Properties!

5 | Questions and Additional Info

F1 Data Analysis

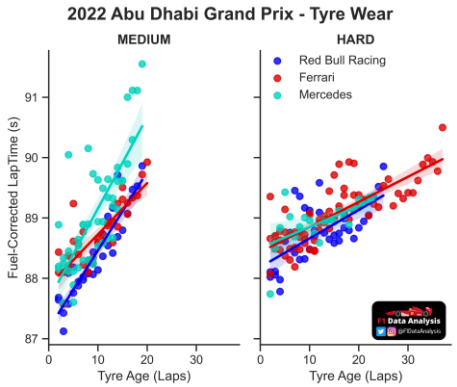
@F1DataAnalysis

Introduction

Who Am I?

Mirco Bartolozzi

- MSc in **Mechanical Engineering**
- **PhD** candidate researching on:
  - Motorcycle Dynamics
  - Riding Simulators
  - Tyre Behaviour
  - Human-Vehicle Interaction
  - Machine Learning for Driving Behaviour
- Formerly *Dynamics & Suspension* Chief for **Firenze Race Team**, currently a team supervisor
- Founder of **F1DataAnalysis**



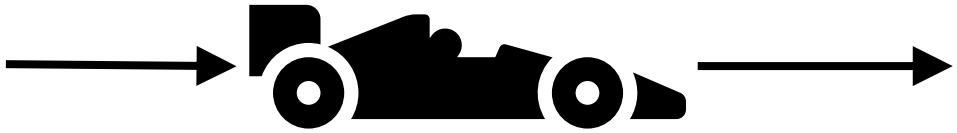
F1 Data Analysis
@F1DataAnalysis

Introduction

Estimation Through Models

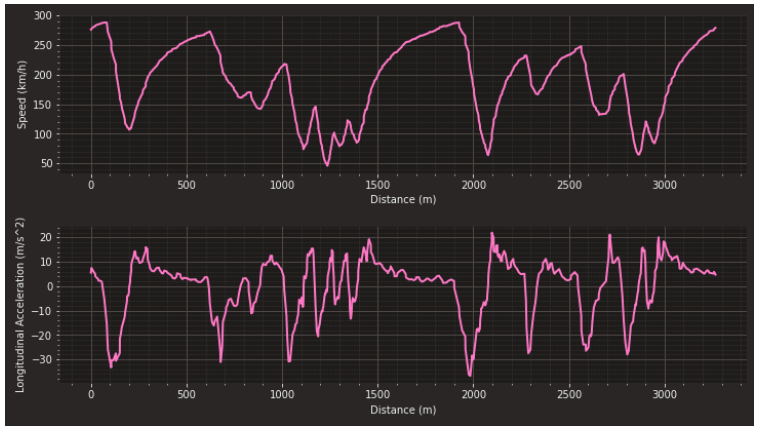
Signals

- **Measured** (Speed)
- **Computed** (Acceleration)



Estimated Signals

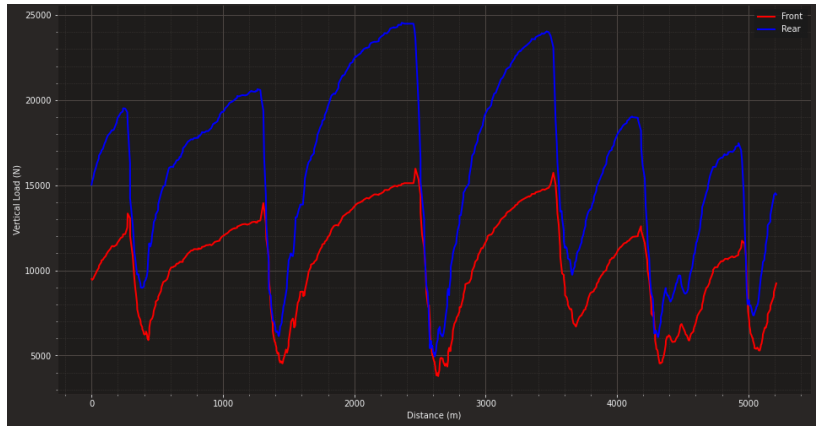
- **Vertical Load on Each axle**



Vehicle Model

- **Equations**
- **Parameters** (Mass, Wheelbase…)

$$F_{\mathrm{f}} = F_{\mathrm{static_f}} + \Delta F_{\mathrm{inertia}}$$
$$F_{\mathrm{r}} = F_{\mathrm{static_r}} - \Delta F_{\mathrm{inertia}}$$
$$F_{\mathrm{static_f}} = \mathrm{FracWeight_f} mg$$
$$F_{\mathrm{static_r}} = mg - F_{\mathrm{static_f}}$$
$$\Delta F_{\mathrm{inertia}} = -\frac{h}{l} ma$$

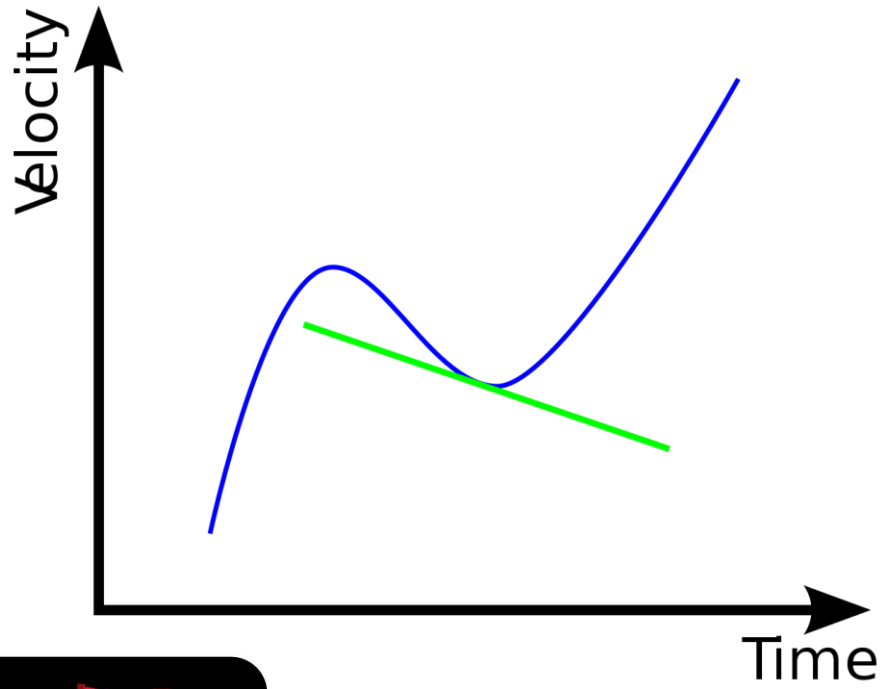


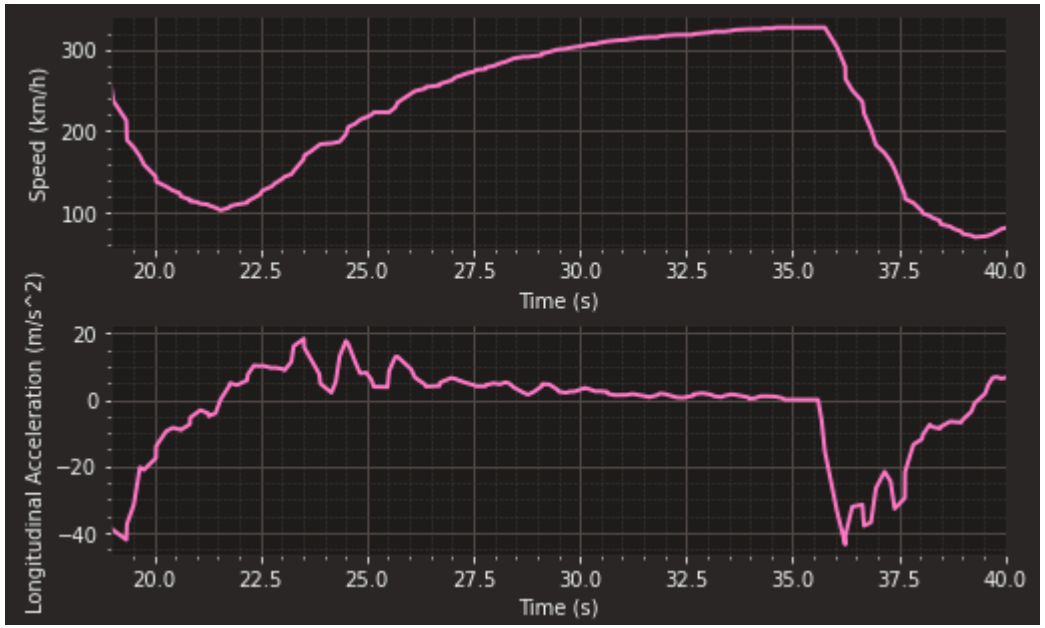
Computing the Longitudinal Acceleration

Longitudinal Acceleration: **rate of change of the car's speed**

- **Positive** when the **speed is increasing** (e.g. race start)
- **Negative** when the **speed is decreasing** (e.g. when braking)

$$a = \frac{dv}{dt}$$

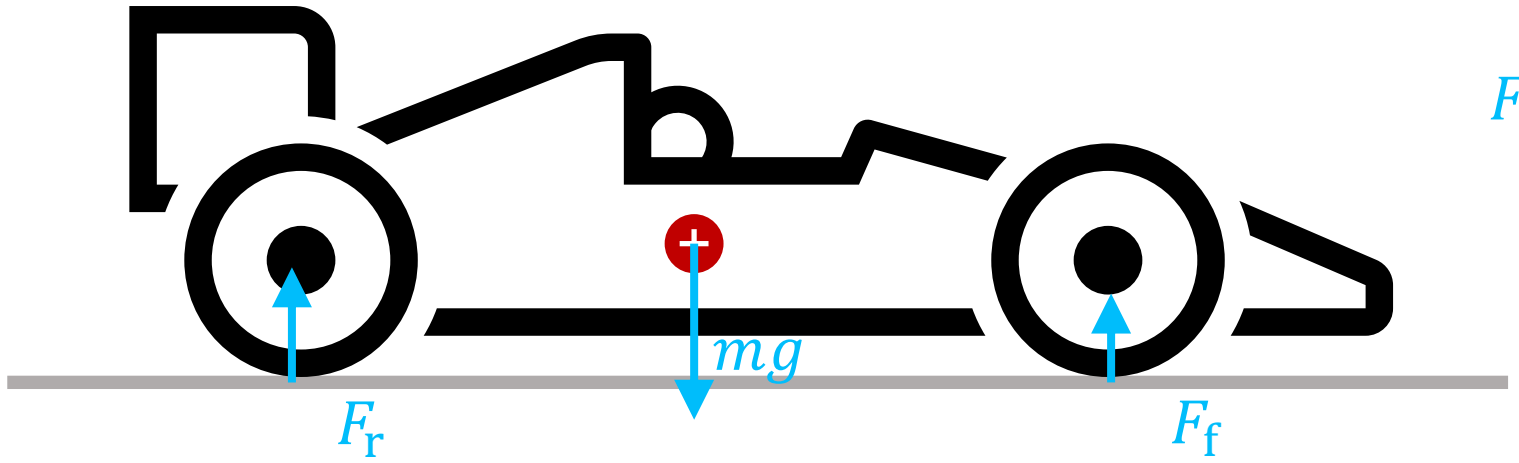




F1 Data Analysis
@F1DataAnalysis

Estimating the Tyre Load

Model I: Static Weight Only

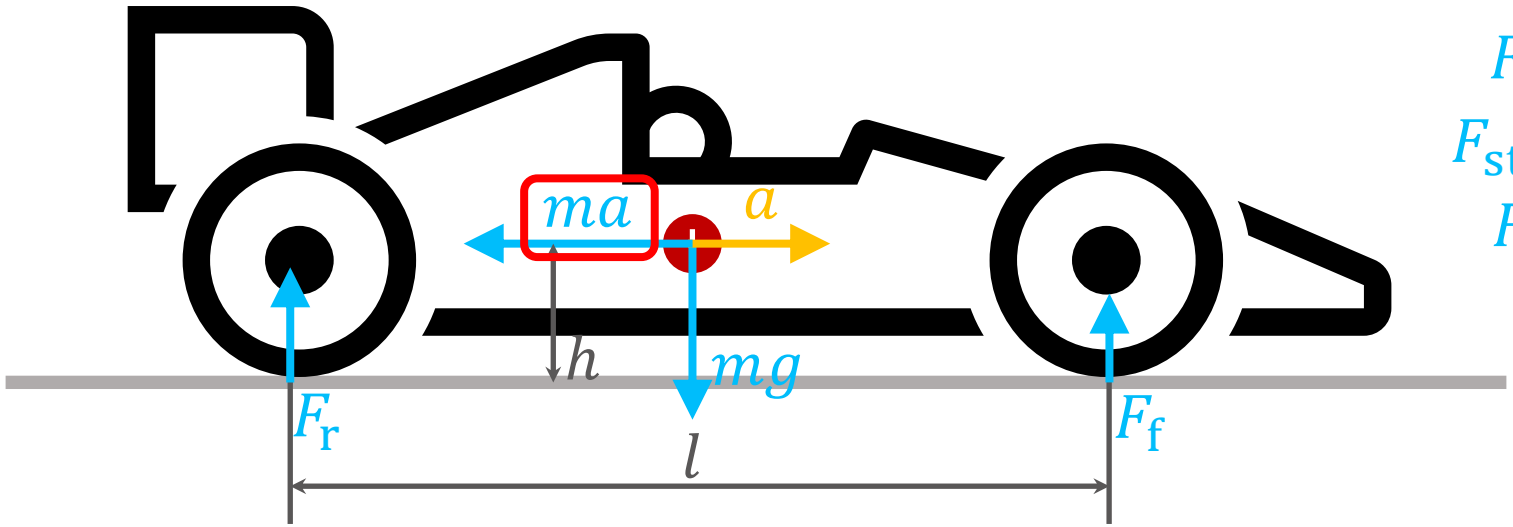


$$F_f = F_{static_f} = \text{FracWeight}_f mg$$

$$F_r = F_{static_r} = mg - F_f$$

Estimating the Tyre Load

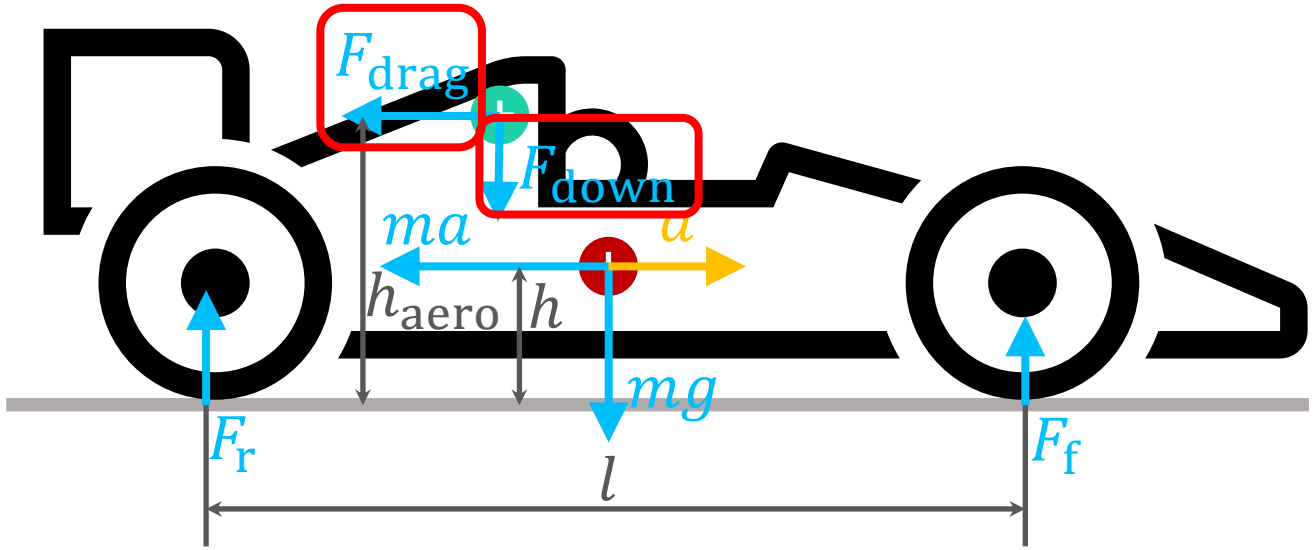
Model II: Inertial Load Transfer



$$F_{\mathrm{f}} = F_{\mathrm{static_f}} + \Delta F_{\mathrm{inertia}}$$
$$F_{\mathrm{r}} = F_{\mathrm{static_r}} - \Delta F_{\mathrm{inertia}}$$
$$F_{\mathrm{static_f}} = \mathrm{FracWeight_f} mg$$
$$F_{\mathrm{static_r}} = mg - F_{\mathrm{static_f}}$$
$$\Delta F_{\mathrm{inertia}} = -\frac{h}{l} ma$$

Estimating the Tyre Load

Model III: Inertial Load Transfer + Aero



$$F_f = F_{static_f} + \Delta F_{inertia} + F_{down_f} + \Delta F_{drag}$$
$$F_r = F_{static_r} - \Delta F_{inertia} + F_{down_r} - \Delta F_{drag}$$

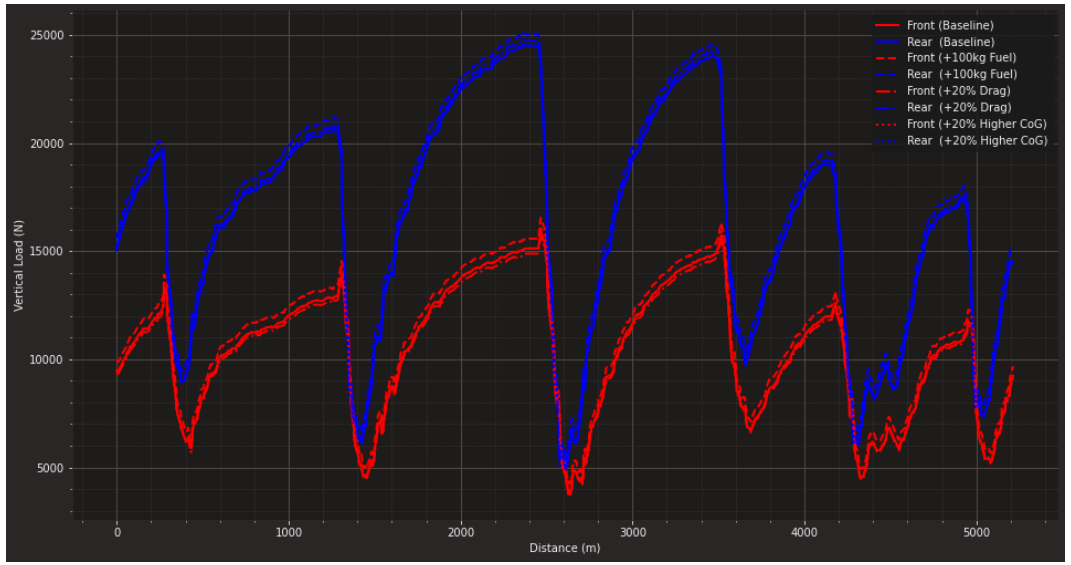
$$F_{static_f} = (\text{FracWeight}_f)mg$$
$$F_{static_r} = mg - F_{static_f}$$
$$\Delta F_{inertia} = -\frac{h}{l}ma$$

$$F_{down_f} = (\text{FracDown}_f)F_{down}$$
$$F_{down_r} = (1 - \text{FracDown}_f)F_{down}$$
$$\Delta F_{drag} = -\frac{h_{aero}}{l}F_{drag}$$
$$F_{down} = 0.5C_l A\rho v^2$$
$$F_{drag} = 0.5C_d A\rho v^2$$

Changing the Car Properties!

Which ones have the most impact?

- Mass + 100kg (Full tank)
- +20% Drag (Monaco vs Abu Dhabi)
- +20% CoG height (Worse Design)



F1 Data Analysis
@F1DataAnalysis

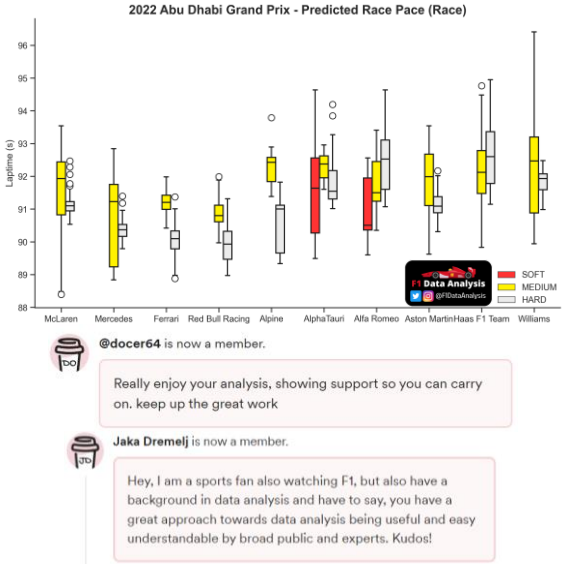
Questions and Next Projects

Stay Updated!

New!

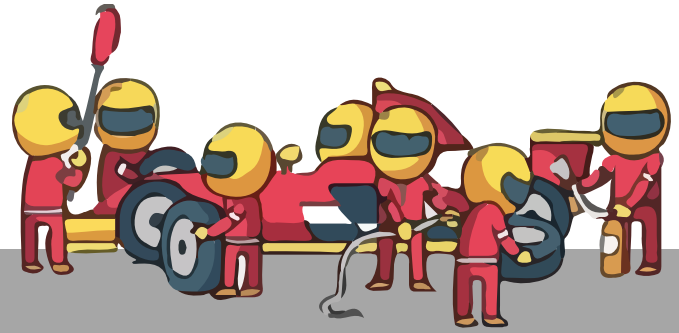
https://linktr.ee/f1dataanalysis

Support the Page and Get Extra Content/Perks!



Questions?

?



F1 Data Analysis
@F1DataAnalysis