Optimal Control Inputs for a Racing Car in a Racing Circuit

Objectives: compare different Quasi steady-state (QSS) Lap Time Simulation (LTS) strategies and choose the best option to develop a GUI for the amateur racer.

Two strategies are employed for modelling the performance envelope:

- Using data acquisition to produce an elliptical GG-Diagram using the maximum accelerations observed and a vehicle model
- Using real tyre friction ellipses to generate a GG-Diagram

Two approaches are compared:

- Classical method: iterative implementation
- Particle Swarm Optimization (PSO): application of Evolutionary Computation

Vehicle model: includes a power curve, a throttle map, drag and rolling resistance effects, and load transfer

Problem formulation:

\[
\begin{align*}
\text{max } & \quad a_x^2 + a_y^2 \\
\text{subject to} & \quad a_x^2 + a_y^2 + b_{yy} \leq 1 \\
& \quad a_y = \frac{V^2}{R}
\end{align*}
\]

Jaguar E-Type low drag (1962) at Silverstone Historic Grand Prix Circuit

Conclusions:

The classical implementation of the first strategy, because of its reduced computation time, accuracy and the ease of acquiring the data inputs needed, has been deemed the most appropriate to develop a LTS GUI for the amateur racer, as long as there are no accused elevation changes and the car does not generate a considerable amount of downforce

Mr. Rafael Martínez Silva

Autonomous Vehicle Dynamics and Control MSc