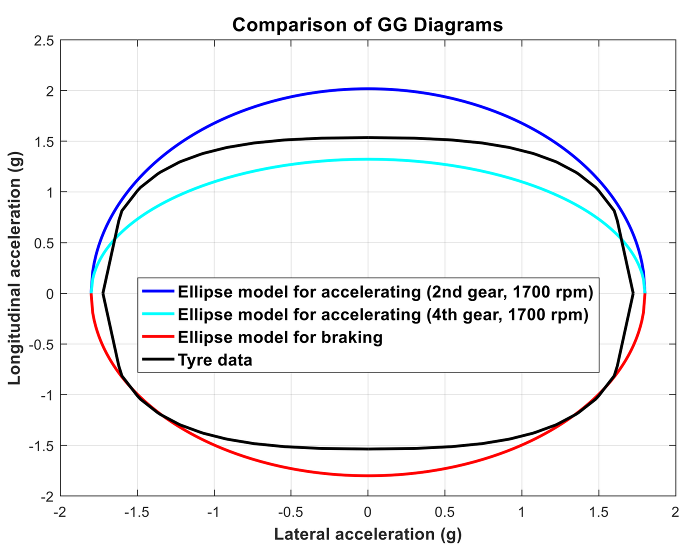
Optimal Control Inputs for a Racing Car in a Racing Circuit

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:

$$\max a_x^2 + a_y^2$$

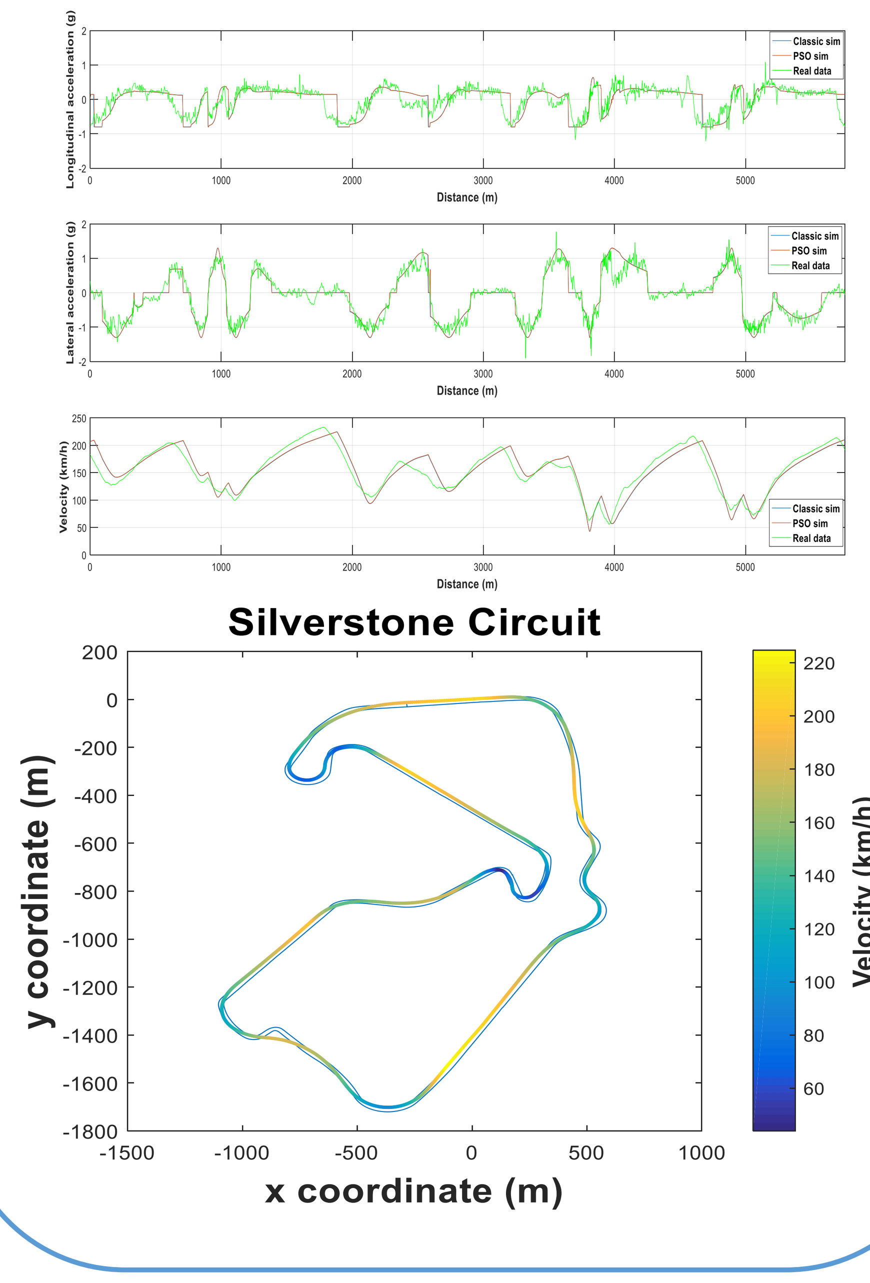
subject to

$$\frac{a_y^2}{a_{gg}} + \frac{a_x^2}{b_{gg}} \leq 1$$

$$a_y = \frac{V^2}{R}$$

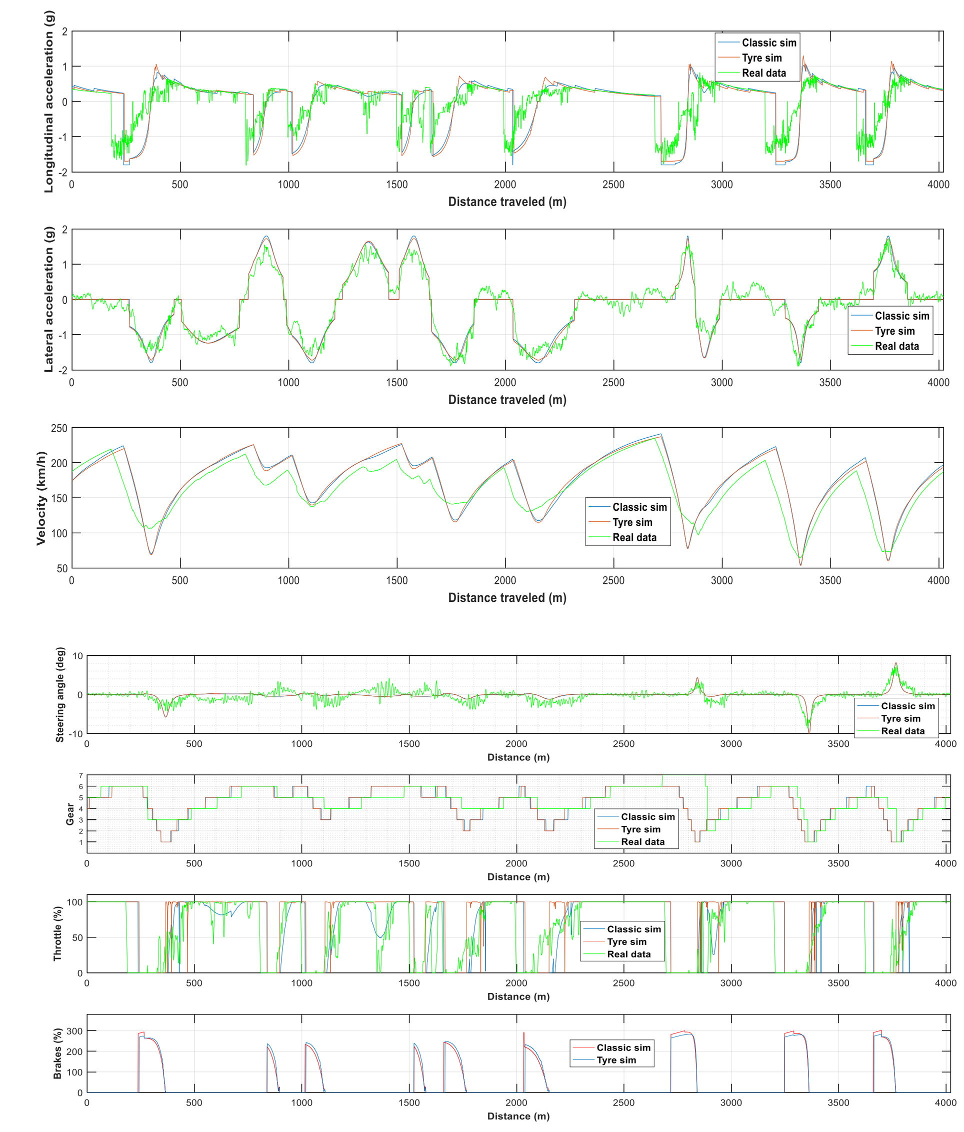
Jaguar E-Type low drag (1962) at Silverstone Historic Grand Prix Circuit

	Real data		Classical simulator	PSO simulator
Lap time (s)	145.60		145.5074	144.6194
Constraint Violations	Tol = 0.001 g	-	3 (0.21 %)	995 (68.29 %)
	Tol = 0.01 g	-	0	615 (42.21 %)
	Tol = 0.1 g	-	0	2 (0.14 %)
Computation time (s)	-		2.2705	338.3422

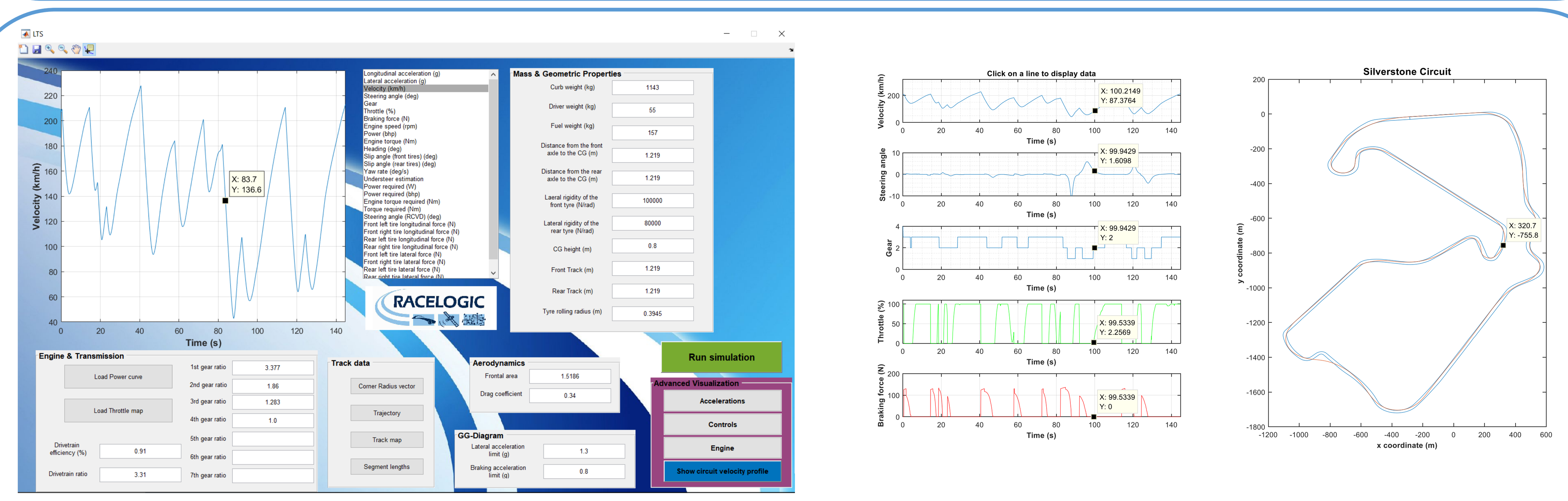


Small open-wheel car at Donington Park Grand Prix Circuit

	Real data		Classical simulator	PSO simulator	Classical simulator (tyre data)	PSO simulator (tyre data)
Lap time (s)	94.18		88.3240	90.3337	88.1766	88.0005
Constraint Violations	Tol = 0.001 g	-	0	2590 (54.98 %)	858 (18.21 %)	2891 (61.37 %)
	Tol = 0.01 g	-	0	800 (16.98 %)	603 (12.80 %)	1519 (32.24 %)
	Tol = 0.1 g	-	0	0	0	4 (0.08 %)
Computation time (s)	-		4.9653	1105.6069	2.1682	1607.3561



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



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