FLUID DYNAMICS ANALYSIS OF A FAIRING FOR A RACING MOTORCYCLE: REDUCTION OF THE AERODYNAMIC DRAG THROUGH ADVANCED OPTIMIZATION ALGORITHMS

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Introduction

In recent years, the reduction of the aerodynamic drag for the vehicles acquired a great importance especially for the reduction of fuel consumption.
The drag reduction can be obtained through two approaches. The first approach relies on experimental tests, where the geometry is modified directly in the wind tunnel to improve the performance of the fairing.
The second approach relies on numerical simulations, where the fairing geometry is modified within CAD softwares and a numerical simulation provides the performance.
The latter method is certainly the most economical since wind tunnels, which have high costs, are not adopted. The geometry variation can be conducted by advanced optimization algorithms to obtain the best result.

Targets

The purpose of the present work is to create an automatic optimization loop that acts on the parametrization of the critical zone of the fairing shape to reduce the aerodynamic drag with a genetic algorithm. The critical zone is shown in figure 1.1.

The work focused on this targets:

- Geometric parametrization
- Automatic loop optimization
- Reduce the aerodynamic drag

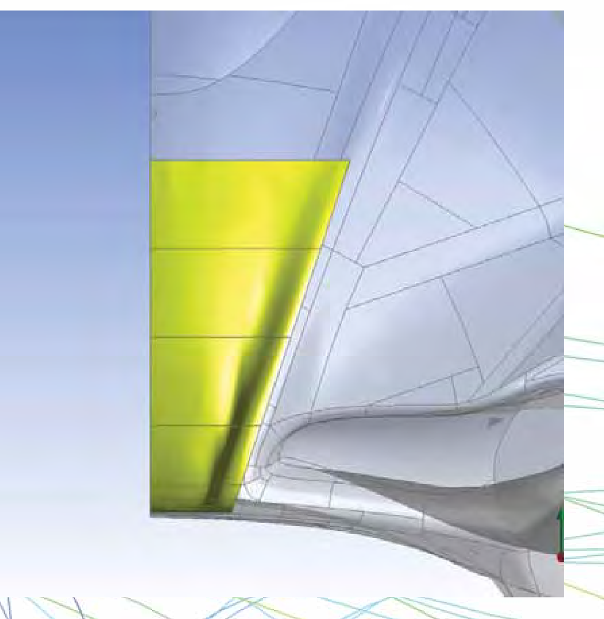

Figura 1.1. Critical zone characterized by the high value of the drag values.

Methods

The method adopted to achieve the goal is changing the fairing shape using a genetic algorithm. As a first step, the critical zone was identified in the front part of fairing and parametrized with a series of two-dimensional Bézier curves extended to the three-dimensional domain using a sweep function. The geometry was therefore described by a cloud of points as shown in figure 1.2.

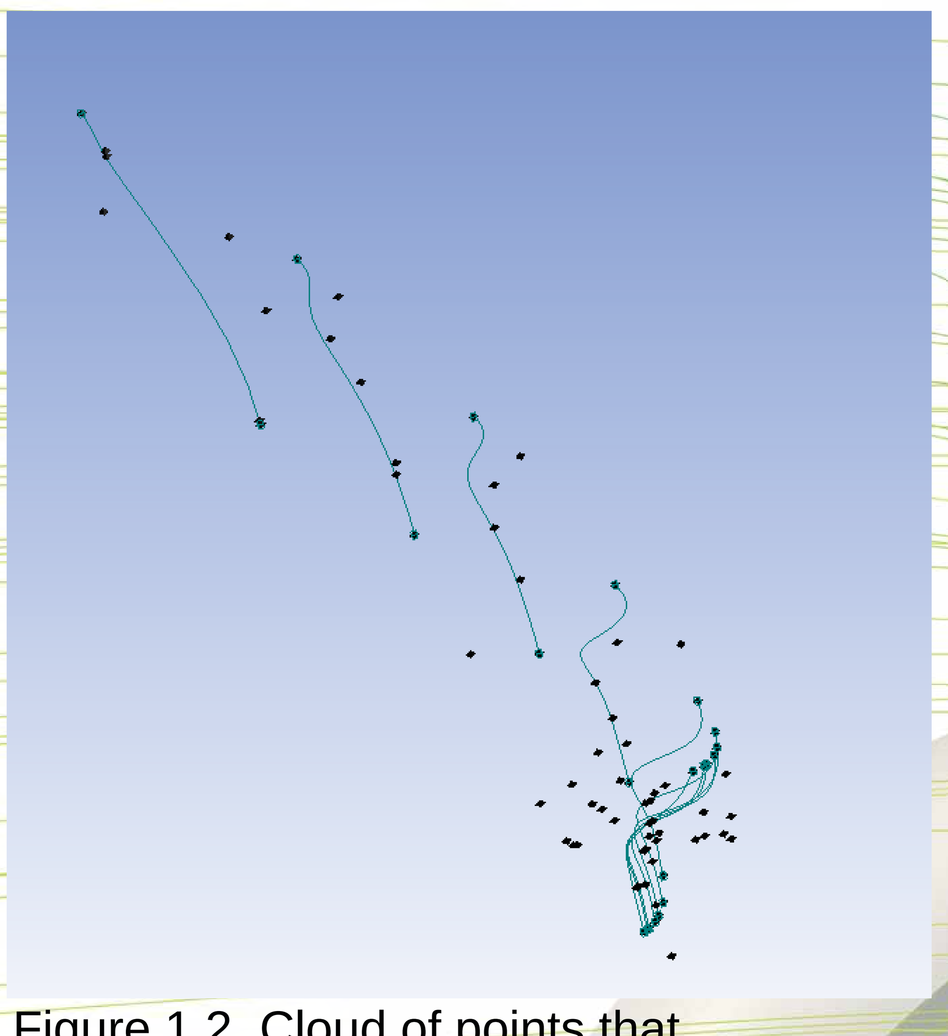

Figure 1.2. Cloud of points that parametrize the geometry.

The variations of the points were correlated to each other to reduce the number of the decisional parameters provided by the optimization algorithm. The optimization loop changes the shape of the fairing to catch the optimal geometry. The points varied by the genetic algorithm were imported within a CAD software to build the geometry. The geometry was meshed using a volume discretization previously validated with a sensitivity study. The flow field was solved by getting values of lift and drag of new geometry.
The lift and drag values were provided to the optimization algorithm to link the control points variations to the aerodynamics resistance. The automatic optimization loop is shown in figure 1.3.

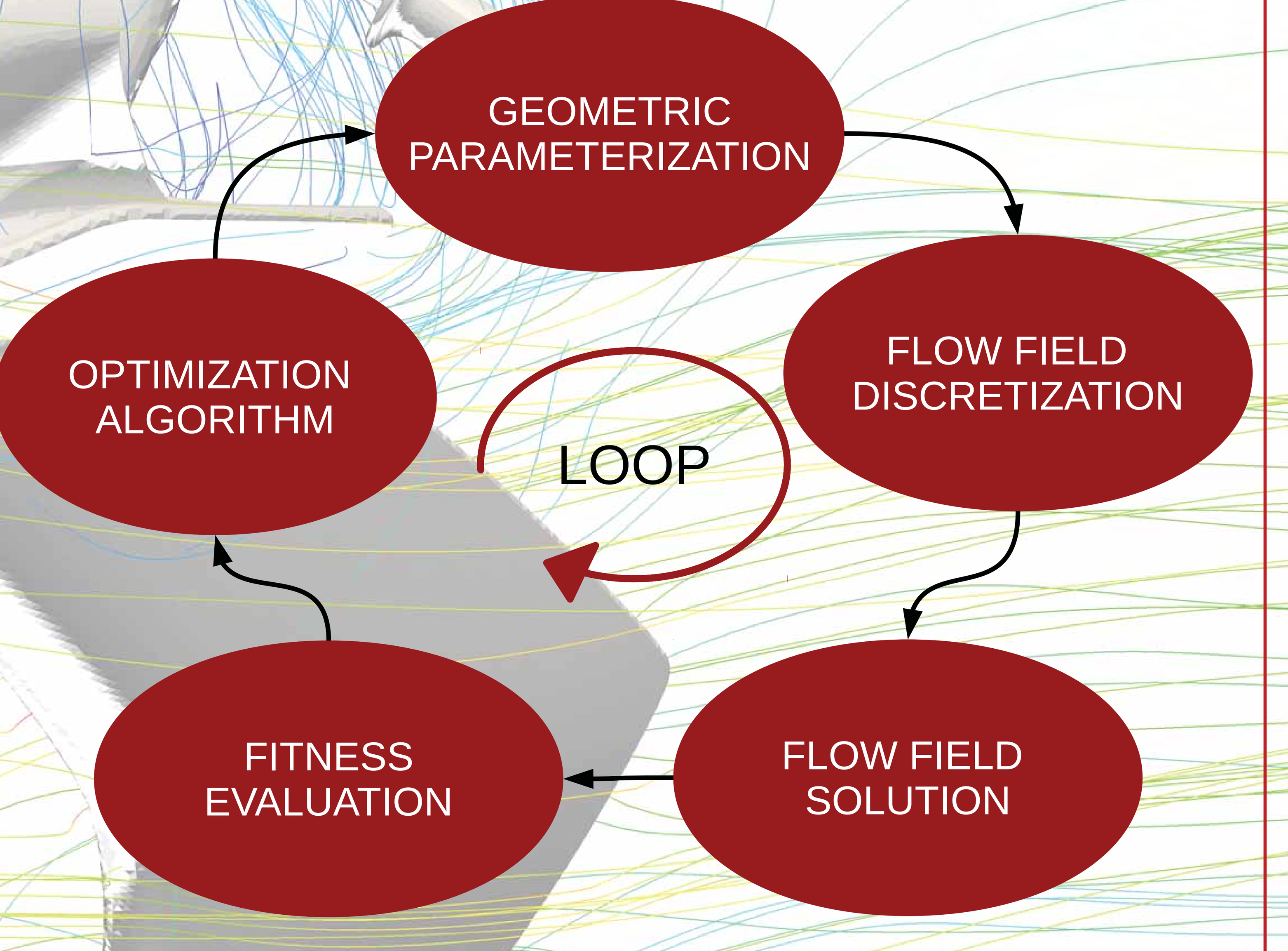

Figure 1.3 Optimization loop.

Results

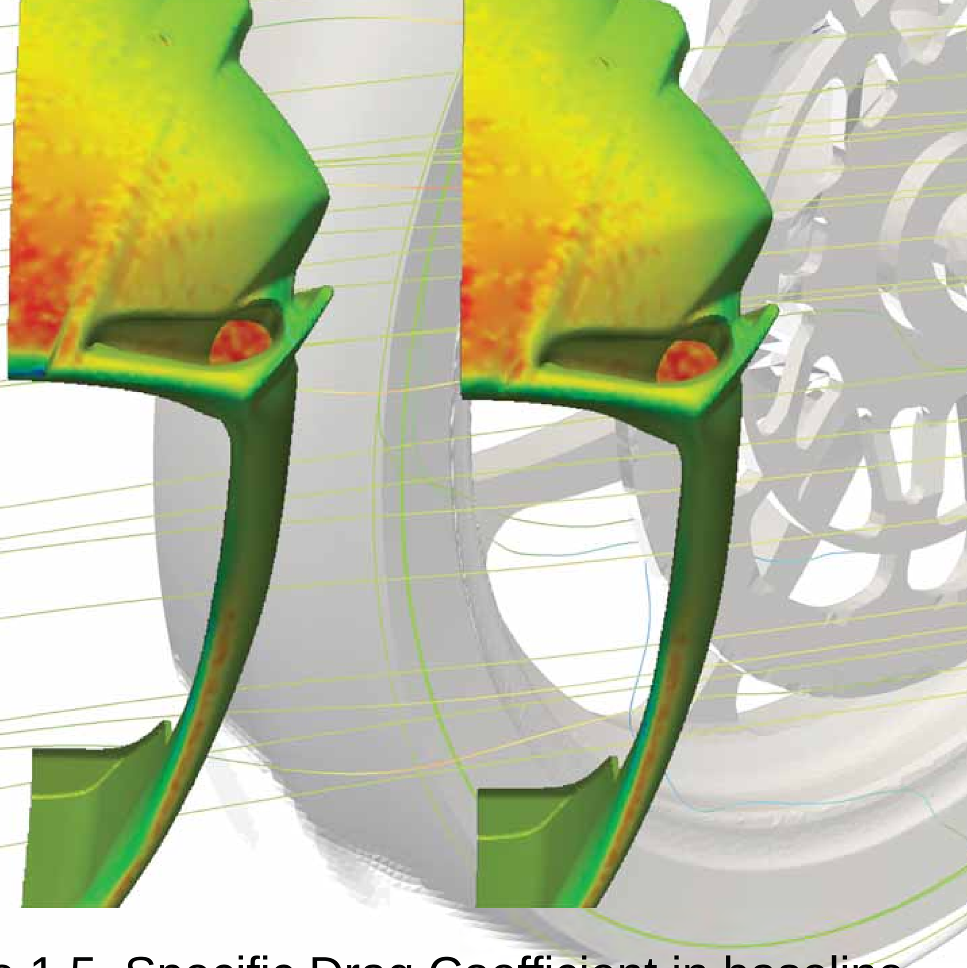

Figure 1.5. Specific Drag Coefficient in baseline (left) and optimized (right).

The algorithm evolved for two generations evaluating a total of 40 different geometries.
The results is showed in figure 1.4. where the Pareto front is shown. Observing the Pareto front, a geometry with a reduction of 4.5% of the drag coefficient is identified. The results of the best geometry are shown in table 1.1. Figure 1.5. shows the drag reduction in the critical zone between the base and the optimized geometry.

	Cd	Cl
Optimized	0,111	-0,013
Baseline	0,116	-0,016
Variation %	-4,5%	16%

Table 1.1. Comparison among optimized and baseline coefficients.

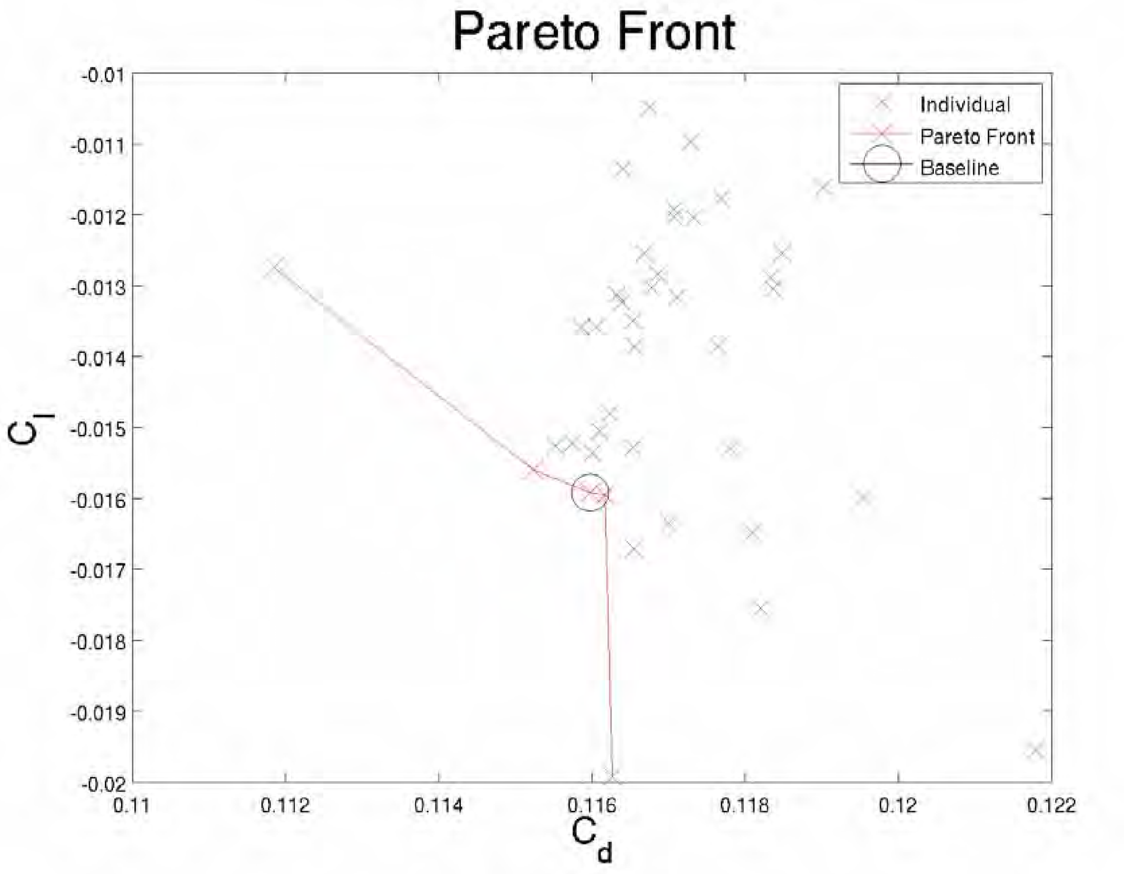

Figure 1.4. Pareto Front for the simulated individual.

Conclusions and Future Works

The creation of an automatic optimization loop for the search of the optimal geometry allowed to obtain a reduction of 4.5% of drag coefficient of the fairing.
Future developments will focus the search for a method of three-dimensional parameter, such as NURBS, and an increase in the number of generations to perform the optimization.