Designing and testing of an automatic virtual wind tunnel tool to support the research on an innovative racing solar cells car

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Introduction. In solar cells racing cars, aerodynamics efficiency impact is of about 50% on the overall final performance being drag reduction the main driving parameter for design improvements. Nevertheless physical wind tunnel analysis can be time consuming during the preliminary design analysis limiting the number of innovative shape evaluation. A virtualized computational approach can be therefore winning. Virtual testing in external aerodynamics is a well-established procedure by means of Reynolds averaged 3D computational Fluid Dynamics (CFD). From a starting baseline design to a final improved design several CFD calculations must be accounted. Moreover external aerodynamics CFD is expensive in terms of licensing costs, computational time and of human time to perform a set of standard activities. CFD automation can be improved by using open-source (no licensing costs) libraries and High Performance Computing (HPC) platforms and a simple automatic workflow to improve usability also by non expert users.

Standard Approach

Activity	CAD Design	CAD Cleaning	Meshing	CFD modelling	Post Processing	Decision making
Human	100%	100%	80%	40%	80%	100%
Computing	0%	0%	20%	60%	20%	0%

Mostly human driven

Main Targets of the Project.

For these reasons, in this project, an **automatic standardized workflow procedure for 3D turbulent external aerodynamics problems has been developed in the open-source CFD Toolbox (OpenFOAM) to take advantage of state-of-the-art HPC systems by means of simple and intuitive text user interface (TUI)**.

Automatic Approach

Activity	CAD Design	CAD Cleaning	Meshing	CFD modelling	Post Processing	Decision making
Human	100%	100%	0%	0%	0%	100%
Computing	0%	0%	100%	100%	100%	0%

Human driven Human driven Automatic Automatic Automatic Human driven

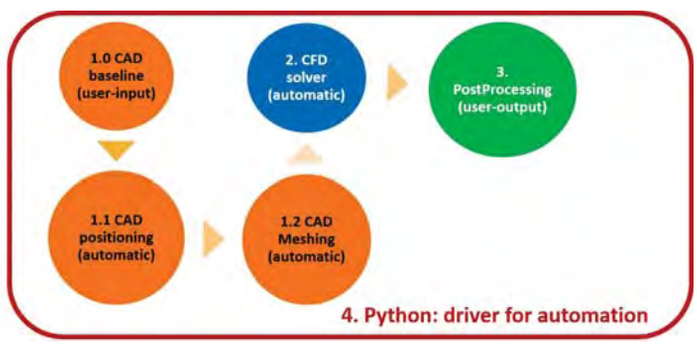
Automatic Bricks.

Mesh: relevant fluid dynamics parameters are driving the mesh refinement layers around the car. Final average mesh size is about 10 millions cells. Fully Automatic.

Solver: incompressible RANS steady state solver, Komega-sst turbulent model with standard wall functions. Fully automatic.

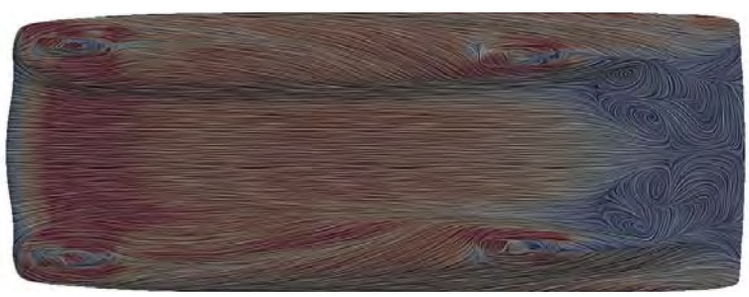
Post-processing: forces and coefficients automatically monitored during calculation, averaged over last 250 iterations, 2D slices and 3D images are saved for future visualization of meaningful fluid dynamics patterns. Fully automatic.

Automation: Python programming language drives the workflow procedure starting from a CAD file and reference velocity including job submission to the HPC system and mailing tracking of the status.



Example of fluid dynamics results output at 80 km/h.

Back View



Bottom View and Side View

Opportunities.

With this automatic tool, based on open-source libraries and HPC system, it is possible to achieve **hundreds of automatic CFD computations in days.**

The workflow thanks to automation can **cut of about 90% the human time wasted in repetitive tasks ensuring always coherent virtual data generation**.

The workflow can be easily used also by **non-expert users** so that designers can **improve design considering drag impact** by means of the virtualized environment.

Perspectives.

The workflow can be extended to include geometry input quality testing and **automatic conversion from different CAD formats**.

Moreover, the workflow can be extended to include **user defined key parameter indexes** to be automatically monitored and plotted. Finally, the workflow can be extended to include **automatic reporting (tables and figures) and mailing to user as PDF file**.

Discussion. The application presented herein shows how an automatic efficient workflow for virtual wind tunnels analysis **can be obtained by means of standardization and automation of existing elementary technological bricks**. The workflow is built using only open-source technologies (OpenFoam) to get the maximum benefits from parallel computing on top of existing HPC platforms.

Future work. The outcomes need to be fully validated over specific wind-tunnel tests data before putting the tool into a production stage.The workflow **need to be tested also by a large set of non-expert** users to assess the real robustness of the solution design. Finally the workflow is a good basis but to be fully exploited by a large group of users a **web GUI is needed allowing for easy and intuitive data interaction and designs comparison.**