Solar Car Streamline Integral Boundary Layer Method

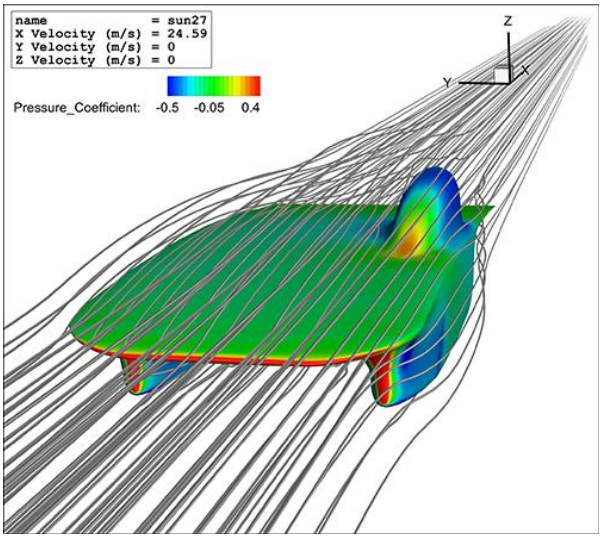
MSc Project Proposal

1. Introduction

The Bridgestone World Solar Challenge is a biennial solar-powered car race which covers 3,022 km through the Australian Outback from Darwin to Adelaide. The objective of this competition is to promote research on solar-powered cars where teams from universities and enterprises participate. The World Solar Challenge is designed to motivate students into science, engineering, technology, and sustainable energy and teaches them the importance of teamwork.

Solar Team Twente consists of students from the University of Twente and Saxion Hogeschool in Enschede. The team started in 2005 and participated in all subsequent races in the Challenger Class where the goal is to travel the distance as quickly as possible.

2. Problem Description



For the design of the aerodynamic shape of the car a combination of analysis methods is in use by Solar Team Twente. For example, the 2D airfoil analysis & design program XFOIL is used to design the longitudinal cross-sections of the body and the wheel cowlings. These cross-sections are then input in the design of the full 3D geometry. This 3D geometry is discretized and a volume grid around the body is generated. The volume grid is then input for a numerical simulation method that solves the Reynolds-averaged Navier-Stokes equations. This design process for the 3D problem is time-consuming. Especially in the preliminary design phase there is a need for a fast numerical tool chain for accurate 3D aerodynamic analysis and design.

In this project you will develop an integral boundary layer method that uses the pressure distribution along a streamline. This streamline pressure distribution is the result of a simulation with a multilevel panel method that models the equations for inviscid and incompressible flow. Part of the work is determining the streamlines by integration the surface velocity vector distribution. The results of such a boundary layer analysis on a solar car geometry can be used to direct the redesign of the car body.

Part of the project are the following elements:

- Literature study
- Mathematical formulation for determining the streamline through a selected point.
- Mathematical formulation of the laminar and turbulent integral boundary equations.
- Mathematical description of a simple laminar-turbulent transition model.
- Discretization of the equations
- Implementation in Fortran
- Aerodynamic analysis of simple 3D geometries and (possibly) a solar car from a previous race
- Discussion of the numerical results
- Report

3. Your profile

- Basic knowledge of fluid dynamics
- Knowledge of numerical analysis and algorithm development
- Knowledge of a high level programming language

4. Project details

- The work will be carried out at University of Twente.
- The duration will be 8 months

5. Literature

Some links to literature on the panel method:

- J. Katz, A. Plotkin, "Low-Speed Aerodynamics", Cambridge University Press, 2001.
- A. van Garrel, "Multilevel Panel Method for Wind Turbine Rotor Flow Simulation", PhD thesis, University of Twente, 2016.

6. Contact information

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