Using image recognition to identify vortices for vehicle design

Hartree Centre
Science & Technology Facilities Council

Researchers based at the STFC Hartree® Centre are working with TotalSim – an aerodynamics and CFD company – to understand vortex formation in Formula One cars and improve aerodynamic performance.

Challenge

Although well-studied, vortices are still not well-defined and have multiple criteria. A vortex can be described as a spinning spiral flow of fluid or air with closed streamlines, each with distinct properties and behaviour. Many components on a modern Formula One car are designed by the aerodynamicists to shed vortices. These vortices are used to control the air flow around the race car in order to maximise the downforce that can be generated. Understanding the dynamics of vortex structures is important as they have a direct impact on vehicle performance. TotalSim were looking to develop an algorithm that could extract, label and track vortices in vehicle simulation data to help identify the most promising design solutions more efficiently.

Approach

Vortices are well-studied in flow visualisation, however those in 3D vector fields are not well-defined and have multiple criteria. The team approached this problem by first treating simulation results as 2D snapshots, applying image processing techniques to identify significant features. This approach is directly applicable to experimental images, enabling comparison and validation of fluid flow modelling. The team were able to develop an algorithm capable of analysing large image sets and highlighting significant features which ultimately helped improve engineering analyses.

Benefits

This work - completed as part of the collaborative Innovation Return on Research (IROR) programme with IBM Research - provided an efficient mechanism of extracting information about wing tip vortices formation in Formula One cars. The algorithm developed is versatile and can be applied to images from both simulations and physical experiments. This work offers detailed insights into the formation of vortex structures, leading to better vehicle designs with enhanced aerodynamic efficiency.

> " This has provided opportunities to work with experts outside our normal field of experience and allowed us to undertake 'blue-sky' research projects that would otherwise be too risky or expensive for an SME like us to undertake. "
>
> Robert Lewis
> TotalSim

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> **"** Cross-industry events organised at the Hartree Centre have provided us with the opportunity to collaborate with and learn from companies with whom we would not otherwise interact. This sharing of ideas is of much benefit to British industry. **"**
>
> Robert Lewis
> TotalSim

At a glance

- Used image processing techniques to label and extract vortices from Formula One vehicle simulation data

- Developed an algorithm capable of analysing large image sets, efficiently identifying significant features

- Offers detailed insights in to vortex formation, helping to identify better vehicle designs

- Insights from image analysis in both simulation and physical experiments to improve vehicle performance

Who we are

- 60+ computational scientists and technologists
- World-leading supercomputing and AI infrastructure
- Bespoke small teams built around your project
- Tailored business development support
- Access to our network of industry, academic and technology partners

What we do

- Boost productivity and enhance innovation for industry
- Big data analytics and artificial intelligence (AI)
- High performance computing and quantum simulation
- Training and skills development
- Insights into emerging technologies

Our impact on UK industry and society

The Hartree Centre was created by UK Government to transform industry by accelerating the adoption of high performance computing (HPC), big data analytics and artificial intelligence (AI) technologies. We play a key role in realising UK Government's Industrial Strategy by stimulating applied digital research and innovation, creating value for the organisations we work with and generating economic and societal impact for the UK.

The Science and Technology Facilities Council (STFC) Hartree Centre is part of UK Research and Innovation.

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