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Object-Based Flow Physics for Aerodynamic Modelling in Real-Time Environments

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Abstract : Object-based flow simulation allows fast computation of arbitrarily complex aerodynamic models made up of simple objects with limited flow interactions. The proposed approach is universally applicable to objects made from arbitrarily scaled ellipsoid primitives at arbitrary aerodynamic attitude and angular rate. The use of a component-based aerodynamic modelling approach increases efficiency by allowing selective inclusion of different physics models at run-time and allows extensibility through the development of new models. Insight into the numerical stability of the model under first order fixed-time step integration schemes is provided by stability analysis of the drag component. The compute cost of model components and functions is evaluated and compared against numerical benchmarks. Model static outputs are verified against theoretical expectations and dynamic behaviour using falling plate data from the literature. The model is applied to a range of case studies to demonstrate the efficacy of its application in extensibility, ease of use, and low computational cost. Dynamically complex multi-body systems can be implemented in a transparent and efficient manner, and we successfully demonstrate large scenes with hundreds of objects interacting with diverse flow fields.

Keywords : aerodynamics, real-time simulation, low-order model, flight dynamics
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