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A MODERN FREE-WAKE PANEL METHOD USING UNSTRUCTURED MESHES

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Abstract: Panel methods have been the de facto tool for aerodynamic analysis in the conceptual and preliminary design phases of aircraft for decades. The aerospace industry has relied on them, initially, when computing resources were poor, as the only practical way of obtaining aerodynamic solutions of arbitrary configurations, and lately, as a fast alternative to higher order CFD methods. Since panel methods allow a 3-dimensional fluid flow to be solved on a 2-dimensional surface mesh, the computation complexity of a problem is considerably reduced. Panel methods date back to the 1960s, therefore, most currently available codebases carry a legacy with them in the form of old procedural code that cannot be easily extended with extra functionality, strict use of structured meshes, user-prescribed wakes for lifting surfaces, inflexible and outdated input file support and, in addition, they tend to not make use of modern hardware technologies such as CPU vectorization and parallelism. In this work, a 3-dimensional panel method using a free-wake model and unstructured meshes is presented. The method utilizes constant source and doublet panels to define the geometry and vortex sheets for wake representation. A half-edge data structure is implemented to efficiently represent unstructured polygonal meshes. Support for several known mesh file formats is included and a flexible input file format is used to allow the user to easily configure the solution process. This work incorporates modern software development practices, such as unit testing and version control, with a generic and object-oriented approach in a modern portable C 17 header-only template library, laying a solid foundation for future applications.