FAST LIFTING PANEL METHOD

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Abstract

Panel methods continue to enjoy widespread and routine use in a variety of aerodynamic and hydrodynamic contexts, especially in preliminary analysis and design. Unlike Euler and Navier-Stokes codes, panel methods do not require a volume grid. Hence they are of considerable value for modeling potential flows about complex geometries and multiple bodies in relative motion. Panel methods are commonly perceived as a mature technology with marginal room for improvement. The present paper seeks to challenge this view and addresses one of the primary limitations of panel methods; namely the quadratic growth in CPU and storage costs with panel number. Using fast summation methods previously applied to a non-lifting panel code, for N panels the $O(N^2)$ computational requirements are reduced to O(NlogN) with minimal loss of accuracy. With such order of magnitude reductions, realistic and detailed surface descriptions containing $O(10^5)$ panels can be accommodated upon readily accessible workstations or even PCs. The present paper outlines the formulation and implementation of a fast lifting panel treatment based upon the Morino formulation and presents results to both confirm the anticipated accuracy and CPU/storage trends and also to demonstrate the ability to accommodate complex realistic configurations with large panel counts.

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Nomenclature

$A_{\alpha;ij}$	influence coefficients defined in Eq.(8)
b_{mk}	multipole coefficients associated with source panels defined in Eq.(15b)
$\underline{B}_{mk}$	multipole coefficients associated with doublet panels defined in Eq.(14b)
$G(\underline{R},\underline{\rho})$	Green's function defined in Eq.(1)
{G}	group of panels
$\underline{n}$	surface normal
N	number of panels
N_b	number of body panels
N_w	number of wake doublet panels
r	distance, $\lvert\underline{R}-\underline{\rho}\rvert$
$\underline{R}$	evaluation (field) location
S	bounding surface
$\underline{u}$	velocity
ϕ	perturbation potential
$\phi_{\{G\}}$	perturbation potential induced by a group of panels, {G}
μ	doublet strength defined in Eq.(3a)
$\underline{\rho}$	source point
σ	source strength defined in Eq.(3b)
ψ_{mk}	'outer' functions defined in Eq.(12b)
Ψ_{mk}	'inner' functions defined in Eq.(12a)
∇_R	Gradient operator, $\partial/\partial\underline{R}$.

Introduction

Panel methods enjoy a long history of successful usage in the aeronautical community and remain an essential tool for the aero- and hydro-dynamicist. Much