

Preface

This book presents aeroservoelasticity (ASE) as a well-formed discipline with a systematic framework. While many research articles have appeared on the special applications of ASE—such as active flutter suppression and gust load alleviation—there are no textbooks and monographs on the general and systematic procedure to be followed in the modeling and analysis of aeroservoelastic systems. This book is a first step in trying to fill this important gap in the aerospace engineering literature. This book introduces the basic math modeling concepts and highlights important developments involved in structural dynamics, unsteady aerodynamics, and control systems. It also attempts to evolve a generic procedure to be applied for ASE system synthesis. The treatment includes finite-element structural modeling and detailed unsteady aerodynamic modeling at various speeds for deriving the necessary aeroelastic plants, with sample control applications to active flutter suppression, load alleviation, and adverse ASE coupling.

A general aeroelastic plant is derived via the finite-element structural dynamic model, unsteady aerodynamic models for various regimes in the frequency domain, and the associated state-space model by rational function approximations. For more advanced models, the full-potential, Euler, and Navier–Stokes methods for treating transonic and separated flows are also briefly addressed. Essential ASE controller design and analysis techniques are introduced to the reader. Introduction to robust control-law design methods of LQG/LTR and H_2/H_∞ synthesis is followed by a brief coverage of nonlinear control techniques of describing functions and Lyapunov functions.

The fundamental concepts are presented in such a way that the most important features can be easily deduced. The breadth of coverage is sufficient for a thorough understanding of ASE.

The focus of this book is on aeroservoelastic modeling, including a brief presentation on robust and optimal control methods that can be applied to important aeroservoelastic design problems. It is not possible to give a more comprehensive ASE treatment in a single book, and it is envisaged that a future book can be devoted to more advanced topics such as adaptive and nonlinear control design techniques.

This book is aimed at graduate students and advanced researchers in aerospace engineering, as well as professional engineers, technicians, and test pilots in the aircraft

industry and laboratories. The reader is assumed to have taken basic undergraduate courses in mathematics and physics—particularly calculus, complex variables, linear algebra, and fundamental dynamics—and is encouraged to review these concepts at several places in the text.

A book on ASE is difficult to write due to the breadth of topics it must necessarily address. While this book covers the essentials of modeling aspects of ASE with some control applications, it gives sufficient motivation to a reader with specific research interests to further explore the relevant topics. Furthermore, the treatment of topics is such that a novice can quickly build up his/her understanding of ASE without much difficulty. References are selected keeping both the types of readers in mind.

This book has been long in writing, with the intention first having occurred to the author about 15 years ago. Not having access to the industrial codes for finite-element and unsteady aerodynamics necessary for building such an exposition, and not finding the time to write one's own codes, the project continued to be delayed until about 2 years ago, when courage was finally gathered for this purpose. Testing and validating the codes for the many examples in the book was itself a formidable task, which required many hours of patient programming.

I would like to thank Walt Eversman for his course on aeroelasticity, and for advising me in my graduate studies. The editorial and production staff of Birkhäuser have offered many constructive inputs during the preparation of the manuscript, for which I am indebted to them. I am also grateful to The MathWorks, Inc. for providing the latest MATLAB/Simulink version utilized for the examples throughout the book.

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