

ADAPTIVE STRUCTURES – SOFT MECHANICAL APPROACH

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ABSTRACT

Since their earliest conceptualization, structures with reconfigurable characteristics contributed to the emergence of an architecture, able to respond and adjust itself to shifting environmental conditions, or time dependent users' needs. In this respect, the development of tensegrity and scissor-like structures to obtain adaptive capabilities, is primarily based on articulated joints and embedded mechanical actuators, following a hard mechanical approach. Although these systems are usually designed to use a small number of components to achieve maximum shape adjustments, their implementation often causes an increase of unsustainable processes with regard to the number and characteristics of the actuators used and mechanisms complexity, as well as energy-inefficient processes, in terms of both construction and kinetic operation. An alternative soft approach for adaptive structures is proposed in the current paper through an implementation of hybrid cable bending-active members, while the latter replaces multiple local hinges through reversible elastic bending deformations. Through the cables own length modification, these are responsible for the structure deformability and sufficient prestressing of the primary elastic members. Such pliable structures increase the level of design complexity due to the inherent elastic properties of the materials used and their nonlinear structural behaviour during transformation. In demonstrating this, a series of single, coupled and coupled-interconnected cable bending-active system configurations are investigated. Results obtained describe the stress distribution between the structural components during the systems' form-finding process and load-bearing behaviour.

Keywords: adaptive structures, cable bending-active structures, finite-element analysis, form-finding, soft mechanical approach.

1 INTRODUCTION

The necessity for overcoming static, heavyweight and energy inefficient building components, triggered the conceptualization and the evolution of adaptive systems [1]. Chronologically, the development of kinetic structures, primarily in terms of deployable tensegrity and scissor-like systems has been influenced by architectural form requirements, aesthetic factors, structural optimisation criteria, performance capacity and economy [2, 3]. So far, such systems are mainly based on kinetic mechanisms followed by hard mechanical approaches, while taking into consideration aspects of self-weight minimisation, modularity, connectivity and constructability [4]. While both aforementioned systems do not provide extensive flexibility, since their motions are limited between a closed and open state, reconfigurable systems have been acknowledged for their enhanced adaptive behaviour in terms of their physical ability to reconfigure themselves in various modular geometries and overall morphologies [5]. In many cases, the use of embedded computation and actuators enables real-time kinetic adaptation and structural control, resulting in unique adaptive responses [6]. Although current developments and implemented examples that attain the above attributes have verified their ability to adapt and support adequate morphological alterations, these are often characterized as complex and energy inefficient [7].

In extent, recent research activities focus on applications of soft, pliable materials, characterised by their passive elastic properties [8]. The alternative soft mechanical approach is based on implementation of elastically deformable members that may vary in shape and assemblage [9]. In principle, elastic deformation acting on primary elastic members can

Modelling And Control Of Adaptive Mechanical Structures

Peter Chen, Victor Martinez-Luaces



Modelling And Control Of Adaptive Mechanical Structures:

Modelling and Control of Adaptive Mechanical Structures Ulrich Gabbert, 1998 **Modelling and Control of Adaptive Mechanical Structures** Ulrich Gabbert, Society of Automotive Engineers, 1999-01-01 Adaptive structures are autonomous structural systems with integrated multifunctional smart materials as actuators and sensors connected by a control system to facilitate adaptation to changing environmental conditions This collection of 48 papers is based on a Euromech 373 colloquium on the subj IUTAM Symposium on Smart Structures and Structronic Systems Ulrich Gabbert, H.S. Tzou, 2012-12-06 Proceedings of the IUTAM Symposium on Smart Structures and Structronic Systems held in Magdeburg Germany 26 29 September 2000 **Smart Materials and Structures** G.R Tomlinson, W.A Bullough, 1998-01-01 Significant changes have occurred in materials science including increasing demands on life extensions and the reliability and exploitability of components materials and structures These changes provide smart technologies with excellent application opportunities in aerospace civil and electrical engineering transportation manufacturing communications defense and medicine Smart Materials and Structures presents an overview of current developments in the characterization and applications of materials and actuators issues surrounding their control and the integration of smart systems and technologies This compendium provides a valuable synopsis of this rapidly expanding and topical research field for engineers program managers technologists physicists materials scientists and mathematicians working to advance smart materials research methods their applications and robotic technologies **Modelling and Control of Adaptive Mechanical Structures** , 1998 *Smart Structures* Azfal Suleman, 2001 This book documents the state of the art evaluation of the embryonic field of multifunctional materials and adaptive structures more specifically in the area of active vibration suppression shape control noise attenuation structural health monitoring smart machines and micro electro mechanical systems with application in aircraft aerospace automobile civil structures and consumer industry International Aerospace Abstracts , 1999 **Smart Technologies for Safety Engineering** Jan Holnicki-Szulc, 2008-04-30 Smart technologies comprise a dynamic new interdisciplinary research field that encompasses a wide spectrum of engineering applications including but not limited to intelligent structures and materials actuators sensors and structural observability control systems and software tools for the design of adaptive structures Smart technologies focus on the issues surrounding the safety and integrity of engineering systems Smart Technologies for Safety Engineering presents the achievements of ten years of research from the Smart Tech Centre applied to some of the key issues of safety engineering Results presented include Original methods and software tools for modelling design simulation and control of adaptive structures and applicability of the adaptive concept to the design of structures for extreme loads Application of the smart tech concept to hot research topics and emerging engineering issues including health monitoring of structures and engineering systems monitoring of loading conditions automatic structural adaptation to unpredictable randomly changing dynamic conditions

and the optimal design of adaptive structures and engineering systems Numerically efficient and original software packages that can be used for the design of adaptive as well as passive without control devices structures The Virtual Distortion Method which has been developed especially for fast reanalysis of structures and systems and exact sensitivity analysis allowing for effective modelling design health monitoring and control of smart engineering systems The original research and practical applications in Smart Technologies for Safety Engineering will appeal to a broad spectrum of engineers researchers professors and graduate students involved in the research design and development of widely understood adaptronics and mechatronics including smart structures and materials adaptive impact absorption health and load monitoring vibration control vibroacoustics and related issues

Wave Motion, Intelligent Structures and Nonlinear Mechanics Herbert Berall, Ardeshir Guran, D. J. Inman, 1995 This book is a collection of papers on the subject of applied system dynamics and control written by experts in this field It offers the reader a sampling of exciting research areas in three fast growing branches i Wave Motion ii Intelligent Structures iii Nonlinear Mechanics The topics covered include flow instability nonlinear mode localization autoparametric systems with pendula and geometric stiffening in multibody dynamics Mathematical methods include perturbation methods modern control theory nonlinear neural nets and resonance scattering theory of Berall Ripoche Maze Applications include sound induced structural vibrations fiber acoustic waveguides vibration suppression of structures linear control of gyroscopic systems and nonlinear control of distributed systems This book shows how applied system dynamics and control is currently being utilized and investigated It will be of interest to engineers applied mathematicians and physicists

Nonlinear Systems and Matrix Analysis - Recent Advances in Theory and Applications Peter Chen, Victor Martinez-Luaces, 2024-11-27 Nonlinear system analysis is of interest to engineers sociologists physicists mathematicians and many other scientists since most systems are inherently nonlinear in nature In mathematics a nonlinear system does not satisfy the superposition principle such as in a linear system Therefore the theories underlining nonlinear analysis and their applications need to be developed on their own merit The first section of this book is a collection of examples reporting recent advances in both theory and applications of nonlinear system analysis The contents of each chapter will provide in depth foresight to interested readers As numerical linearization to a set of matrix equations is still the principal method used to solve a nonlinear system matrix analysis is the topic of the second section of this book The matrices have invaded practically all areas of mathematics the experimental and social sciences engineering and technology This volume updates purely mathematical theoretical aspects and it also presents concrete examples of the wide range of applications of matrix theory in other disciplines

Applied mechanics reviews, 1948 *Technology for Large Space Systems*, 1987

Smart Civil Structures You-Lin Xu, Jia He, 2017-04-11 A smart civil structure integrates smart materials sensors actuators signal processors communication networks power sources diagonal strategies control strategies repair strategies and life cycle management strategies It should function optimally and safely in its environment and maintain

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and Systems in the Space Station Era ,1991-12 *Scientific and Technical Aerospace Reports* ,1994 Nonlinear Science And Complexity - Proceedings Of The Conference Albert C J Luo,Liming Dai,Hamid R Hamidzadeh,2006-12-09 This volume provides useful tools in Lie group analysis to solve nonlinear partial differential equations Many of important issues in nonlinear wave dynamics and nonlinear fluid mechanics are presented Homotopy techniques are used to obtain analytical solutions fundamental problems and theories in classic and quantum dynamical systems are discussed and numerous interesting results about dynamics and vibration in sensor and smart systems are presented Interval computation and nonlinear modeling in dynamics and control are also briefly included **Man-Machine Interactions 4**

Aleksandra Gruca,Agnieszka Brachman,Stanisław Kozielski,Tadeusz Czachórski,2015-10-01 This book provides an overview of the current state of research on development and application of methods algorithms tools and systems associated with the studies on man machine interaction Modern machines and computer systems are designed not only to process information but also to work in dynamic environment supporting or even replacing human activities in areas such as business industry medicine or military The interdisciplinary field of research on man machine interactions focuses on broad range of aspects related to the ways in which human make or use computational artifacts systems and infrastructure This monograph is the fourth edition in the series and presents new concepts concerning analysis design and evaluation of man machine systems The selection of high quality original papers covers a wide scope of research topics focused on the main problems and challenges encountered within rapidly evolving new forms of human machine relationships The presented material is structured into following sections human computer interfaces robot control embedded and navigation systems bio data analysis and mining biomedical signal processing image and motion data processing decision support and expert systems pattern recognition fuzzy systems algorithms and optimisation computer networks and mobile technologies and data management systems

NASA Technical Memorandum ,1991 **Proceedings of 2020 Chinese Intelligent Systems Conference** Yingmin Jia,Weicun Zhang,Yongling Fu,2020-09-29 The book focuses on new theoretical results and techniques in the field of intelligent systems and control It provides in depth studies on a number of major topics such as Multi Agent Systems Complex Networks Intelligent Robots Complex System Theory and Swarm Behavior Event Triggered Control and

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