

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

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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 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 Modelling and Control of Adaptive Mechanical Structures , 1998 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

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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

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Modelling And Control Of Adaptive Mechanical Structures Book Review: Unveiling the Magic of Language

In a digital era where connections and knowledge reign supreme, the enchanting power of language has are more apparent than ever. Its power to stir emotions, provoke thought, and instigate transformation is actually remarkable. This extraordinary book, aptly titled "**Modelling And Control Of Adaptive Mechanical Structures**," written by a highly acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound impact on our existence. Throughout this critique, we will delve in to the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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