

A physics-informed, vision-based method to reconstruct all deformation modes in slender bodies

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Abstract.—This paper is concerned with the problem of self-sensing, interpolating and reconstructing the shape (given and the six modes of deformation) of a slender flexible body from multiple camera measurements. This problem is important in both biology, where slender, soft, and elastic structures are ubiquitous environmental sensor organs, and in engineering, particularly in the area of soft-robotics. The proposed mathematical formulation for shape estimation is physics-informed, based on the use of the spatial C-moment and theory where equations describe slender body mechanics in the presence of bending, shearing, twisting and stretching. The approach is used to derive numerical algorithms which are experimentally demonstrated for three-dimensional and multi-defect soft robot arms. These experimental demonstrations show that the methodology is accurate (all arm poses) even when there are large shape distortions and subject to noise and uncertainty.

1. Introduction

Biological structures that are slender or possess slender appendages, exploit the elasticity and compliance afforded by these features to perform and simplify a variety of tasks, from locomotion (insects, fish, birds) [23–26] to manipulation (octopuses, elephants, giraffes) [7]–[10], and more generally to sensing, adapt and respond to environmental interactions. Bio-inspired slender structures are also being increasingly incorporated in engineering, and particularly in robotics, as sensor (skin, structure and adaptive) [18]–[22]. Nevertheless, despite over a decade of soft-robotics research, we have only begun to appreciate the remarkable series that exist between elasticity, control and environmental context. Thus, to support and advance biological discovery and engineering applications, as well as to model and understand and innovative efforts, there is a growing interest in accurate, robust, cost-effective, and non-invasive techniques for shape and motion estimation in slender flexible bodies.

The problem of shape-motion estimation is complicated because elastic elements, whether biological or artificial, are subject to long-range stress propagation effects, where all six modes of deformation (translational bending and shear, twist and stretch) can be simultaneously engaged. As a consequence, localized loads are concentrated along the entire span of a nonlinear flexible, leading to complex dynamics and global morphological reconfigurations [2,3], [14]. There are among the mechanisms involved in critically contribute to



Fig. 1. Camera and model in experimental setup. A soft 300° serpentine [22] is integrated in our vision-based system. The 300° is connected to three parallel actuators, independently actuated by compressors (a). Actuation signal are generated from Raspberry Pi using MATLAB, and are relayed to 300° robot (b). (c) [22] [23] [24] are robot sensor systems.

animals' superior agility, dexterity, and ability to cope with external factors, safety and robustness. Consequently, they have important implications [20] in terms of body architectural organization, structure and control [7], [26]–[28]. Hence the impending need, for correct morphological incorporation, of methods able to quantify these experiments all continuous deformations, particularly in the presence of highly non-linearly and elastically living or elastically materials [17].

The goal of this paper is to develop and demonstrate methods and algorithms to estimate, from multiple camera images, the continuous bend, shear, twist and stretch strain functions along the longitudinal axis of a slender flexible body, in 3D space. The vision-based approach is selected here because it is versatile, relatively inexpensive, does not interfere with the system and can be deployed in a variety of conditions and environments.

The contributions of this paper are twofold. The theoretical contribution is a novel approximation formulation to estimate both slender body's pose and its associated six strain functions from discrete measurements. The formulation is physics-informed, based on the use of C-moment and theory [27] where equations describe slender body mechanics in the presence of bending, shearing, twisting and stretching. A

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The Informed Vision

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The Informed Vision:

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and recenter their attention on the intellectual originality and creativity of all young people In this way CEC provides valuable tools in the work of creating more equitable and democratic classrooms Such tools are needed in a broader environment that overvalues instrumental approaches to achieving specified learning outcomes Readers will find practices that empower and sustain the deep intellectual engagement of all learners Integrating classroom narratives and other forms of documentation this resource illustrates the kinds of profound changes in understanding that have occurred for teacher candidates as a result of working with CEC Book Features Opens both the teacher educator and teacher candidates to new ways of teaching learning and being in classrooms Demonstrates how the practice works to counter deficit thinking by revealing students brilliance Uses narratives and other forms of documentation to characterize the potential of CEC within a diverse array of teacher education classrooms Portrays the many ways in which CEC has been integrated into different disciplinary and institutional settings illustrating the common intellectual and interpersonal dynamics at work Chapter authors all studied Critical Exploration in the Classroom CEC with its originator Eleanor Duckworth Contributors Elizabeth Cavicchi Eleanor Duckworth Fiona Hughes McDonnell Keri Gelenian Houman Harouni Yeh Hsueh Susan Rauchwerk Lisa Schneier William Shorr Bonnie Hao Kuo Tai Practicing Pragmatism through Progressive Pedagogies Susan Jean Mayer, 2023-12-01 This book contributes to the contemporary revival of pragmatism as a practical and ultimately as Mayer argues necessary philosophical stance within democratic schools Given that pragmatism addresses the question of how people can move forward in the absence of transcendent Truth the author shows how pragmatism also and not incidentally provides grounds for pluralistic democratic societies to move forward in the absence of shared belief systems Weaving together philosophical analysis and classroom discourse research Mayer explores the relationships among pragmatism progressive educational theory and democratic knowledge construction processes and their implications for enacting progressive educational practices in schools Several original research based heuristics that can serve in reliably identifying studying and orchestrating distinctively democratic knowledge construction processes are presented The importance of granting all students a share of interpretive authority is also emphasized For in learning to observe and reflect on one s own terms attend closely to the observations and interpretations of one s peers and reason collaboratively in a transparent and principled manner young people are enculturated into essential democratic values commitments and practices This book is written for a general audience and is intended for all those concerned with strengthening the democratic character of schools and societies It is likely to appeal to scholars researchers and practitioners with interests in philosophy and classroom discourse and curriculum studies as well as philosophers of education and the social sciences more broadly

Colonial Space J.K. Noyes, 2012-10-12 First Published in 1992 This book is about space of a colony and how it was produced It began as a study of the literature of the German colony of South West Africa between the years 1884 and 1915 The author s aim is to demonstrate the active role which literature had played in structuring the experience of the colony If it

could be shown that literature not only describes but also helps to structure the forms of experience then it would follow that it also plays an important role in structuring the experience of colonization and hence the form of the colony itself From the outset therefore the study was concerned with a number of issues centering around colonization representation experience and social form where spatiality is the concept which allows us to understand how these various aspects of colonialism interrelate Dante's Aesthetics of Being Warren Ginsberg,1999 Explores the domain of the aesthetic in Dante

Archaeology and The Politics of Vision in a Post-Modern Context Vítor Oliveira Jorge,Julian Tomas,2009-01-14 Archaeology is intimately connected to the modern regime of vision A concern with optics was fundamental to the Scientific Revolution and informed the moral theories of the Enlightenment And from its inception archaeology was concerned with practices of depiction and classification that were profoundly scopic in character Drawing on both the visual arts and the depictive practices of the sciences employing conventionalised forms of illustration photography and spatial technologies archaeology presents a paradigm of visualised knowledge However a number of thinkers from Jean Paul Sartre onwards have cautioned that vision presents at once a partial and a politicised way of apprehending the world In this volume authors from archaeology and other disciplines address the problems that face the study of the past in an era in which realist modes of representation and the philosophies in which they are grounded in are increasingly open to question **Education through the Arts for Well-Being and Community** Catherine Burke,Peter Cunningham,Lottie Hoare,2020-12-30 Education through the Arts for Well Being and Community examines Sir Alec Clegg s distinctive contribution to education reform Revisiting the significance of Clegg s principles for education in the 21st century the book investigates the impact of his innovative approach to education and his advocacy of an arts based curriculum to promote physical and mental health The book explores a variety of perspectives on Clegg s working relationships career and achievements Sir David Attenborough s foreword remembers his uncle Alec as a lively young teacher and Sir Tim Brighouse considers Clegg as a model for his own leadership in educational reform Eight authors in all bring a range of academic and professional insights to this study of an exceptional educationalist Clegg s national influence as Chief Education Officer in Yorkshire and his impact on schools teacher education and wider communities through an integrated approach to the arts are richly illustrated in text and pictures Two aspects of his work have particular topical relevance Clegg s emphatic concern for children in distress and his encouragement of creativity through teacher education This book will be of great interest for academics scholars and students in the field of the history of education educational policy and reform and all concerned with the role of schools in young people s development *Professional Education, Capabilities and the Public Good* Melanie Walker,Monica McLean,2013-10-01 This book innovatively explores how universities might be engines of reform and be directed towards social change Using rich case studies drawn from South African research the book comprehensively provides a myriad of new perspectives on what constitutes a set of appropriate public good professional capabilities that will translate successfully into

contributions to human development It challenges universities to produce professionals who have the knowledge skills and values to improve the lives of people living in poverty in urban and rural settings It covers issues such as Conceptualising Public Good Professionalism Global Issues and Professional Education South African Debates about Higher Education Institutional conditions and professional education arrangements Social Constraints on educating ethically aware public professionals By drawing on an approach that focuses on differing public good professional capabilities in five professions this book produces a crucial new framework for the preparation of professionals relevant to the global study of higher education policy It expands higher education s contribution to global social justice beyond a concern with human capital administering a challenge to higher education internationally to address human development in the 21st century This book will be of great interest to all scholars of higher education involved in higher education studies comparative education and development studies It will also prove valuable to policy makers higher education leaders and lecturers and graduate professionals in diverse organizations

The Value of Vision in Leadership Paradiso-Testa, Maria, 2025-07-09 Vision is essential for leadership through uncertainty and change of business Vision provides a direction and it inspires action in individuals to accomplish a task Leaders with a clear vision shape the future and culture of the workplace through goals and motivating others In an increasingly complex world visionary leadership enables organizations to remain focused resilient and innovative cultivating a sense of meaning that transcends day to day tasks The Value of Vision in Leadership embraces a global interdisciplinary framework connecting vision to innovation and passion It addresses the ways to aspire to and achieve victory in the areas of education the arts ministry business entrepreneurship and life Covering topics such as artificial intelligence flexible leadership and mentorship This book is an excellent resource for leaders researchers entrepreneurs district administrators educators educational coaches technology specialists business professionals policymakers and many more

From Brand Vision to Brand Evaluation Leslie De Chernatony, 2006 Presenting the reader with practical applications for brand enhancement this book helps to understand the implement strategies to strengthen brands It offers a framework for brand management and provides a flowchart for progressing the brand building process from strategy through tactics to implementation

A Protestant Vision G. J. R. Parry, 2002-08-22 This book sets an Elizabethan intellectual s worldview in the broader context of European Protestant thought

Community Vision and Leadership in Practice Chris Maser, Holly V. Campbell, 2023-07-31 This book is about building and maintaining involved sustainable and inclusive communities from the ground up during a period of unprecedented growth and global change It explains the concepts and principles of community and sustainability and provides students with a framework of sustainable community planning to put into practice It is also designed to help communities everywhere identify and reconnect the true essence of their ecological setting with the objective of raising their quality of life by increasing social environmental and economic sustainability Features Provides up to date frameworks for sustainable community planning processes and case studies on community

planning Explains tools for sustainable planning in accessible non specialist language Illustrates a roadmap to an inclusive collaborative future Explains aspects of sustainable community planning to maximize ecological ecosystem services and climate co benefits simultaneously Includes discussion questions and suggestions following each chapter Intended for undergraduate and graduate students taking leadership and community courses with an emphasis on sustainable practices and ethics as well as for citizens and professionals involved in community projects related to sustainability the authors provide a forward thinking approach showing readers that they are capable of making a positive impact on the future of community development through sustainable approaches and ethical leadership practices The Philosophy of Plato

Plato,1928 Human Development and Community Engagement through Service-Learning Ntimi Nikusuma Mtawa,2019-12-16 This book establishes community engagement and service learning as pathways to advancing human development and common good Using the human development and capability approach as normative frameworks with South Africa as a frame of reference the author investigates the theoretical contributions and ultimate benefits of university community partnerships In doing so this book demonstrates that three interrelated capabilities affiliation common good professionals and local citizenship are developed through community engagement and service learning Subsequently the notion of transformative change through community engagement and service learning is illuminated particularly when operating within the context of power differentials inequality and extreme poverty This book will be of interest and value to students and scholars of service learning and its implications for partnerships between universities and external communities

The Future of Teaching ,2023-02-06 Teaching born of the period of the ancient sages developed as the moral art of living that introduced humanity to teaching as a moral pursuit to the formation of value to a moral and religious mode of being and to a set of moral principles that have survived into the modern day The idea that the future of teaching represents a technological disruption of moral traditions of teaching and what teaching might become has become a serious concern for the current generation of philosophers in both China and the West *Examining Science Teaching in Elementary School from the Perspective of a Teacher and Learner* Margery Osborne,2014-01-21 Osborne examines the way relationships between subject matter teacher and children are constructed in the context of teaching science in the lower elementary grades This is a study of how relationships evolve how they are initiated and how they change over time as the components interact and effect one another *The SAGE Encyclopedia of Classroom Management* W. George Scarlett,2015-02-24 A teacher s ability to manage the classroom strongly influences the quality of teaching and learning that can be accomplished Among the most pressing concerns for inexperienced teachers is classroom management a concern of equal importance to the general public in light of behavior problems and breakdowns in discipline that grab newspaper headlines But classroom management is not just about problems and what to do when things go wrong and chaos erupts It s about how to run a classroom so as to elicit the best from even the most courteous group of students An array of skills is needed to produce such

a learning environment The SAGE Encyclopedia of Classroom Management raises issues and introduces evidence based real world strategies for creating and maintaining well managed classrooms where learning thrives Students studying to become teachers will need to develop their own classroom management strategies consistent with their own philosophies of teaching and learning This work aims to open their eyes to the range of issues and the array of skills they might integrate into their unique teaching styles Key Features 325 signed entries organized in A to Z fashion across two volumes Reader s Guide grouping related entries thematically References Further Readings and Cross References sections Chronology in the back matter Resource Guide in the appendix This encyclopedia is an excellent scholarly source for students who are pursuing a degree or position in the field of education The SAGE Encyclopedia of Classroom Management is an ideal source for all academic and public libraries

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