

Set Differential Equations and Flow Invariance

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The study of Set Differential Equations is initiated in the metric space of nonempty, compact, convex subsets of \mathbb{R}^n , endowed with the Hausdorff metric. The existence of a generalized solution for the associated initial value problems is proved when the function involved does not satisfy any continuity assumptions. Utilizing the ideas of nonsmooth analysis, a proximal aiming condition is employed to investigate the weak and strong invariance for these solutions.

Keywords: Set differential equations; Euler solutions; Proximal normal; Weak and strong invariance

AMS Subject Classifications: 34A60; 49K24

1. PRELIMINARIES

Let $\mathcal{K}_c(\mathbb{R}^n)$ denote the collection of all nonempty, compact and convex subsets of \mathbb{R}^n . Define the Hausdorff metric

$$D[A, B] = \max\left[\sup_{x \in B} d(x, A), \sup_{y \in A} d(y, B)\right] \quad (1.1)$$

where $d[x, A] = \inf\{d(x, y) : y \in A\}$, A, B are bounded sets in \mathbb{R}^n . We note that $\mathcal{K}_c(\mathbb{R}^n)$ with this metric is a complete metric space.

It is known that if the space $\mathcal{K}_c(\mathbb{R}^n)$ is equipped with the natural algebraic operations of addition and nonnegative scalar multiplication, then $\mathcal{K}_c(\mathbb{R}^n)$ becomes a semilinear metric space which can be embedded as a complete cone into a corresponding Banach space.

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Differential Equations Flow Invariance

A. H. Pavel



Differential Equations Flow Invariance:

Tangency, Flow Invariance for Differential Equations, and Optimization Problems Nicolae H. Pavel, Dumitru Motreanu, 1999-04-14 Provides a great deal of material that is completely new to the field of flow invariance offering fresh insights for experienced mathematicians and rigorous training for students new to the specialty Four useful appendices supply the methods used throughout the book making it a totally self referential and self contained unit Features many results that are exclusive to the authors

Differential Equations, Flow Invariance and Applications Nicolae H. Pavel, 1984 *Differential Equations, Flow Invariance and Applications* A. H. Pavel, 1986-05-01

Flow Invariance for Delay Differential Equations Yen Fook Chang, 1978 *Flow-invariant sets for autonomous second order differential equations and applications in mechanics* Nicolae H. Pavel, Corneliu Ursescu, 1980

Group Invariance in Engineering Boundary Value Problems R. Seshadri, T.Y. Na, 2012-12-06

REFEREN CES 156 9 Transforma tion of a Boundary Value Problem to an Initial Value Problem 157 9 0 Introduction 157 9 1 Blasius Equation in Boundary Layer Flow 157 9 2 Longitudinal Impact of Nonlinear Viscoplastic Rods 163 9 3 Summary 168 REFERENCES 168 10 From Nonlinear to Linear Differential Equa tions Using Transformation Groups 169 10 1 From Nonlinear to Linear Differential Equations 170 10 2 Application to Ordinary Differential Equations Bernoulli s Equation 173 10 3 Application to Partial Differential Equations A Nonlinear Chemical Exchange Process 178 10 4 Limitations of the Inspectional Group Method 187 10 5 Summary 188 REFERENCES 188 11 Miscellaneous Topics 190 11 1 Reduction of Differential Equations to Algebraic Equations 190 11 2 Reduction of Order of an Ordinary Differential Equation 191 11 3 Transformat ion From Ordinary to Partial Differential Equations Search for First Integrals 193 11 4 Reduction of Number of Variables by Multiparameter Groups of Transformations 194 11 5 Self Similar Solutions of the First and Second Kind 202 11 6 Normalized Representation and Dimensional Consideration 204 REFERENCES 206 Problems 208 220 Index Chapter 1 INTRODUCTION AND GENERAL OUTLINE Physical problems in engineering science are often described by dif ferential models either linear or nonlinear There is also an abundance of transformations of various types that appear in the literature of engineer ing and mathematics that are generally aimed at obtaining some sort of simplification of a differential model

Differential Geometry Applied to Dynamical Systems Jean-Marc Ginoux, 2009 This book aims to present a new approach called Flow Curvature Method that applies Differential Geometry to Dynamical Systems Hence for a trajectory curve an integral of any n dimensional dynamical system as a curve in Euclidean n space the curvature of the trajectory OCo or the flow OCo may be analytically computed Then the location of the points where the curvature of the flow vanishes defines a manifold called flow curvature manifold Such a manifold being defined from the time derivatives of the velocity vector field contains information about the dynamics of the system hence identifying the main features of the system such as fixed points and their stability local bifurcations of codimension one center manifold equation normal forms linear invariant manifolds straight lines planes hyperplanes In the

case of singularly perturbed systems or slow fast dynamical systems the flow curvature manifold directly provides the slow invariant manifold analytical equation associated with such systems Also starting from the flow curvature manifold it will be demonstrated how to find again the corresponding dynamical system thus solving the inverse problem

Global existence for nonautonomous perturbed differential equations and flow-invariance Nicolae H. Pavel, 1981 *Differential Equations Invariant Under One-parameter Transformation Groups* Suchat Chantip, 1973

Viability, Invariance and Applications Ovidiu Carja, Mihai Necula, Ioan I. Vrabie, 2007-07-18 The book is an almost self contained presentation of the most important concepts and results in viability and invariance The viability of a set K with respect to a given function or multi function F defined on it describes the property that for each initial data in K the differential equation or inclusion driven by that function or multi function to have at least one solution The invariance of a set K with respect to a function or multi function F defined on a larger set D is that property which says that each solution of the differential equation or inclusion driven by F and issuing in K remains in K at least for a short time The book includes the most important necessary and sufficient conditions for viability starting with Nagumo's Viability Theorem for ordinary differential equations with continuous right hand sides and continuing with the corresponding extensions either to differential inclusions or to semilinear or even fully nonlinear evolution equations systems and inclusions In the latter i e multi valued cases the results based on two completely new tangency concepts all due to the authors are original and extend significantly in several directions their well known classical counterparts New concepts for multi functions as the classical tangent vectors for functions Provides the very general and necessary conditions for viability in the case of differential inclusions semilinear and fully nonlinear evolution inclusions Clarifying examples illustrations and numerous problems completely and carefully solved Illustrates the applications from theory into practice Very clear and elegant style

Ordinary Differential Equations: A Dynamical Point Of View Stephen Wiggins, 2023-08-15 Ordinary differential equations is a standard course in the undergraduate mathematics curriculum that usually comes after the first university calculus and linear algebra courses taken by a mathematics major Such courses may also typically be attended by undergraduates from other areas of physical and social sciences and engineering The content of such a course has remained fairly static over time despite the expansion of the topic into other disciplines as a result of the dynamical systems point of view This core undergraduate course updated from the dynamical systems perspective can easily be covered in one semester with room for projects or more advanced topics tailored to the interests of the students

Advances in Automatic Control Mihail Voicu, 2012-12-06 During the academic year 2002-2003 the Faculty of Automatic Control and Computer Engineering of Ia i Romania and its Departments of Automatic Control and Industrial Informatics and of Computer Engineering respectively celebrated 25 years from the establishment of the specialization named Automatic Control and Computer Engineering within the framework of the former Faculty of Electrical Engineering of Ia i and at the same time 40 years since the first courses on Automatic Control and

Computers respectively were introduced in the curricula of the former specializations of Electromechanical Engineering and Electrical Power Engineering at the already mentioned Faculty of Electrical Engineering The reader interested to know some important moments of our evolution during the last five decades is invited to see the Addendum of this volume where a short history is presented And to highlight once more the nice coincidences it must be noted here that in 2003 our Technical University Gheorghe Asachi of Ia i celebrated 190 years from the emergence of the first cadastral engineering degree course in Ia i thanks to the endeavor of Gheorghe Asachi which is today considered to be the beginning of the engineering higher education in Romania Generally speaking an anniversary is a celebration meant to mark special events of the past with festivities to be performed solemnly and publicly according to a specific ritual

Systems Theory with Engineering Applications Mihail Voicu, 2021-09-09 This book presents in a rigorous and comprehensible way the mathematical description and analysis of linear dynamic systems and the controllability and observability of linear dynamic systems It also details the stability of linear dynamic systems automatic control systems and nonlinear dynamic systems and the optimal control of dynamic systems The treatment is both systemic and synthetic achieving rigorous and applicative solutions and is illustrated with engineering examples The book will appeal to scientists working in the practice of systems theory

engineering automatic control computer science electrical engineering electronics and applied mathematics in biology and economics as well as scientists working in education research design and industry

Geometry in the Neighborhood of Invariant Manifolds of Maps and Flows and Linearization Urs Kirchgraber, K. J. Palmer, 1990

Existence and Flow Invariance of Solution to Non-autonomous Partial Differential Delay Equations Seyedeh Marzieh Ghavidel, 2007

Intelligent Systems and Technologies Junzo Watada, 2009-06-17 Intelligent systems and technologies are increasing finding their ways in our daily lives This book presents a sample of recent research results from key researchers The contributions include Introduction to intelligent systems A Fuzzy Density Analysis of Subgroups by means of DNA Oligonucleotides Evolution of Cooperating Classification Rules with an Archiving Strategy to Underpin Collaboration Designing Agents with Dynamic Capability Localized versus Locality Preserving Representation Methods in Face Recognition Tasks Invariance Properties of Recurrent Neural Networks Solving Bioinformatics Problems by Soft Computing Techniques Transforming an Interactive Expert Code into a Statefull Service and a Multicoreenabled System Ro WordNet with Paradigmatic Morphology and Subjectivity Mark up Special Cases of Relative Object Qualification using the AMONG Operator Effective Speaker Tracking Strategies for Multi party Human Computer Dialogue The Fuzzy Interpolative Control for Passive Greenhouses GPS safety system for airplanes 3D Collaborative Interfaces for E learning Open Projects in Contemporary E Learning Software Platform for Archaeological Patrimony Inventory and Management The book is directed to the graduate students researchers professors and the practitioner of intelligent systems

Symmetries and Differential Equations George W. Bluman, Sukeyuki Kumei, 2013-03-14 A major portion of this book discusses work which

has appeared since the publication of the book *Similarity Methods for Differential Equations* Springer Verlag 1974 by the first author and J D Cole The present book also includes a thorough and comprehensive treatment of Lie groups of transformations and their various uses for solving ordinary and partial differential equations No knowledge of group theory is assumed Emphasis is placed on explicit computational algorithms to discover symmetries admitted by differential equations and to construct solutions resulting from symmetries This book should be particularly suitable for physicists applied mathematicians and engineers Almost all of the examples are taken from physical and engineering problems including those concerned with heat conduction wave propagation and fluid flows A preliminary version was used as lecture notes for a two semester course taught by the first author at the University of British Columbia in 1987 88 to graduate and senior undergraduate students in applied mathematics and physics Chapters 1 to 4 encompass basic material More specialized topics are covered in Chapters 5 to 7

Hamiltonian Flows and Evolution Semigroups Henryk Gzyl,1990 [Existence and Flow Invariance of Solutions to Non-autonomous Partial Differential Delay Equations](#) ,2007

Ordinary Differential Equations Herbert Amann,2011-04-20 The series is devoted to the publication of monographs and high level textbooks in mathematics mathematical methods and their applications Apart from covering important areas of current interest a major aim is to make topics of an interdisciplinary nature accessible to the non specialist The works in this series are addressed to advanced students and researchers in mathematics and theoretical physics In addition it can serve as a guide for lectures and seminars on a graduate level The series de Gruyter Studies in Mathematics was founded ca 30 years ago by the late Professor Heinz Bauer and Professor Peter Gabriel with the aim to establish a series of monographs and textbooks of high standard written by scholars with an international reputation presenting current fields of research in pure and applied mathematics While the editorial board of the Studies has changed with the years the aspirations of the Studies are unchanged In times of rapid growth of mathematical knowledge carefully written monographs and textbooks written by experts are needed more than ever not least to pave the way for the next generation of mathematicians In this sense the editorial board and the publisher of the Studies are devoted to continue the Studies as a service to the mathematical community Please submit any book proposals to Niels Jacob

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