

S -Motzkin paths with catastrophes and air pockets (very early version)

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Abstract

So called S -Motzkin paths are combined the concepts ‘catastrophes’ and ‘air pockets’. The enumeration is done by properly set up bivariate generating functions which can be extended using the kernel method.

Keywords: S -Motzkin path; catastrophe; kernel method; air pocket.

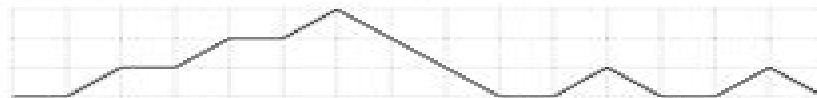
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1. Introduction

Dyck paths consist of up-steps $(1, 1)$ and down-steps $(1, -1)$, start at the origin and do not go below the x -axis; they appear in many texts, we just give one major reference, [12]. Typically, the path returns to the x -axis at the end, but we also consider the scenario of open paths, where the paths end at level j , say. A popular variation of Dyck paths are Motzkin paths: the difference is just that now a horizontal step $(1, 0)$ is also allowed.

In this paper, we concentrate on S -Motzkin paths, which is a subfamily of all Motzkin paths: all three steps (up, level, down) must appear n times, and, ignoring the down-steps, the sequence is $(1, 0)(1, 1)(1, 0)(1, 1)(1, 0)(1, 1) \dots (1, 0)(1, 1)$. The follow figure shows how these paths are recognized: The two layers enforce that the flat and up steps are interlaced. Only paths that end in the origin are S -Motzkin but we consider all paths wherever they end.

Here is an example of such an S -Motzkin path with 15 steps:



Now we present a graph (automaton) to recognize exactly the S -Motzkin paths:



Figure 1: Graph to recognize S -Motzkin paths; they start and end at the special state (origin).

This subfamily of Motzkin paths originated from a question in a student competition; see [10] and [7] for history and analysis. In the following we will combine this family with catastrophes and air pockets, both originating in papers by Jean-Luc Baril and his team [5], [3]; the older paper by Banderier and Wallner [2] might be called the standard reference for lattice paths with catastrophes. The very recent papers [4,5] contain some bijective aspects. Our own paper [9] investigates the situation in the context of skew Dyck paths.

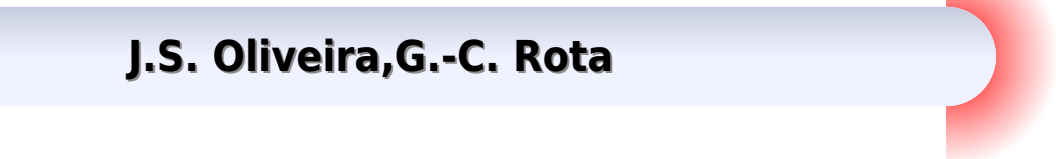
Dyck (and other lattice) paths with catastrophes are characterized by additional steps (‘catastrophes’) that bring the path back to the x -axis in just one step from any level $j \geq 2$. For S -Motzkin paths the definition is similar, and the graphical description in Figure 2 is easiest to understand; the catastrophes are drawn in special colors.

In the last section, S -Motzkin paths with air pockets will be discussed. Briefly, down steps of any length are now allowed, but no two down steps may follow each other.

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Selected Papers Of Theodore S Motzkin

J.S. Oliveira, G.-C. Rota



Selected Papers Of Theodore S Motzkin:

Selected Papers of Theodore S. Motzkin Cantor, 1983-01-01 **Selected Papers** Joseph L. Walsh, 2000-02-11 This volume is a selection from the 281 published papers of Joseph Leonard Walsh former US Naval Officer and professor at University of Maryland and Harvard University The nine broad sections are ordered following the evolution of his work Commentaries and discussions of subsequent development are appended to most of the sections Also included is one of Walsh s most influential works A closed set of normal orthogonal function which introduced what is now known as Walsh Functions **Theodore S. Motzkin** Theodore Samuel Motzkin, 1983 **Selected Papers on Algebra and Topology by Garrett Birkhoff** J.S. Oliveira, G.-C. Rota, 1987-01-01 The present volume of reprints are what I consider to be my most interesting and influential papers on algebra and topology To tie them together and to place them in context I have supplemented them by a series of brief essays sketching their historical background as I see it In addition to these I have listed some subsequent papers by others which have further developed some of my key ideas The papers on universal algebra lattice theory and general topology collected in the present volume concern ideas which have become familiar to all working mathematicians It may be helpful to make them readily accessible in one volume I have tried in the introduction to each part to state the most significant features of each paper reprinted there and to indicate later developments The background that shaped and stimulated my early work on universal algebra lattice theory and topology may be of some interest As a Harvard undergraduate in 1928-32 I was encouraged to do independent reading and to write an original thesis My tutorial reading included de la Vallée Poussin s beautiful *Cours d Analyse Infinitesimale* Hausdorff s *Grundzüge der Mengenlehre* and Fréchet s *Espaces Abstraits* In addition I discovered Carathéodory s 1912 paper *Über das lineare Mass von Punktmengen* and Hausdorff s 1919 paper on *Dimension und Ausseres Mass* and derived much inspiration from them A fragment of my thesis analyzing axiom systems for separable metrizable spaces was later published 2 This background led to the work summarized in Part IV **Selected Papers of Norman Levinson** J.A. Nohel, D.H. Sattinger, Gian-Carlo Rota, 1997-12-18 The deep and original ideas of Norman Levinson have had a lasting impact on fields as diverse as differential integral equations harmonic complex stochastic analysis and analytic number theory during more than half a century Yet the extent of his contributions has not always been fully recognized in the mathematics community For example the horseshoe mapping constructed by Stephen Smale in 1960 played a central role in the development of the modern theory of dynamical systems and chaos The horseshoe map was directly stimulated by Levinson s research on forced periodic oscillations of the Van der Pol oscillator and specifically by his seminal work initiated by Cartwright and Littlewood In other topics Levinson provided the foundation for a rigorous theory of singularly perturbed differential equations He also made fundamental contributions to inverse scattering theory by showing the connection between scattering data and spectral data thus relating the famous Gel fand Levitan method to the inverse scattering problem for the Schrödinger equation He was the first to analyze and make explicit use of

wave functions now widely known as the Jost functions Near the end of his life Levinson returned to research in analytic number theory and made profound progress on the resolution of the Riemann Hypothesis Levinson's papers are typically tightly crafted and masterpieces of brevity and clarity It is our hope that the publication of these selected papers will bring his mathematical ideas to the attention of the larger mathematical community

Theory of Linear and Integer

Programming Alexander Schrijver, 1998-06-11 Theory of Linear and Integer Programming Alexander Schrijver Centrum voor Wiskunde en Informatica Amsterdam The Netherlands This book describes the theory of linear and integer programming and surveys the algorithms for linear and integer programming problems focusing on complexity analysis It aims at complementing the more practically oriented books in this field A special feature is the author's coverage of important recent developments in linear and integer programming Applications to combinatorial optimization are given and the author also includes extensive historical surveys and bibliographies The book is intended for graduate students and researchers in operations research mathematics and computer science It will also be of interest to mathematical historians

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References Notation index Author index Subject index

Lectures On Convex Sets (Second Edition) Valeriu

Soltan, 2019-11-28 The book provides a self contained and systematic treatment of algebraic and topological properties of convex sets in the n dimensional Euclidean space It benefits advanced undergraduate and graduate students with various majors in mathematics optimization and operations research It may be adapted as a primary book or an additional text for any course in convex geometry or convex analysis aimed at non geometers It can be a source for independent study and a reference book for researchers in academia The second edition essentially extends and revises the original book Every chapter is rewritten with many new theorems examples problems and bibliographical references included It contains three new chapters and 100 additional problems with solutions

NBS-INA, the Institute for Numerical Analysis, UCLA

1947-1954 Magnus Rudolph Hestenes, 1991 Real Algebraic Geometry and Ordered Structures Charles N. Delzell, James J.

Madden, 2000 This volume contains 16 carefully refereed articles by participants in the Special Semester and the AMS Special Session on Real Algebraic Geometry and Ordered Structures held at Louisiana State University and Southern University Baton Rouge The 23 contributors to this volume were among the 75 mathematicians from 15 countries who participated in the special semester Topics include the topology of real algebraic curves Hilbert's 16th problem moduli of real algebraic curves effective sums of squares of real forms Hilbert's 17th problem efficient real quantifier elimination subanalytic sets and stratifications semialgebraic singularity theory radial vector fields exponential functions and valuations on nonarchimedean ordered fields valued field extensions partially ordered and lattice ordered rings rings of continuous functions spectra of rings and abstract spaces of higher level orderings and real places This volume provides a good overview of the state of the art in this area in the 1990s It includes both expository and original research papers by top workers in this thriving field The authors and editors strived to make the volume useful to a wide audience including students and researchers interested in real algebraic geometry and ordered structures two subjects that are obviously related but seldom brought together

Mathematics Related to Physics Raoul Bott, 1994 Volume 4 *Topics in Hyperplane Arrangements, Polytopes and Box-Splines* Corrado De Concini, Claudio Procesi, 2010-08-30 Topics in Hyperplane Arrangements Polytopes and Box Splines brings together many areas of research that focus on methods to compute the number of integral points in suitable families or variable polytopes The topics introduced expand upon differential and difference equations approximation theory cohomology and module theory This book written by two distinguished authors engages a broad audience by providing a strong foundation This book may be used in the classroom setting as well as a reference for researchers

Topics in Mathematical Economics and Game Theory Robert J. Aumann, Myrna Holtz Wooders, 1999 Among his contributions to game theory economics and mathematics Aumann introduced the concept of acceptable points As this endeared him to many game theorists a reprint of his seminal 1959 paper on Acceptable Points in General Cooperative n Person Games leads the 17 offerings on cooperative and non cooperative game theory and economics and social choice A number of these papers or related works were presented at the Fields Institute Conference New Directions in the Theory of Markets and Games held October 1995 in Toronto honoring Aumann The conference program concludes the text Lacks an index Annotation copyrighted by Book News Inc Portland OR

Even Convexity and Optimization María D. Fajardo, Miguel A. Goberna, Margarita M.L. Rodríguez, José Vicente-Pérez, 2020-10-27 This tutorial is the first comprehensive introduction to possibly infinite linear systems containing strict inequalities and evenly convex sets The book introduces their application to convex optimization Particular attention is paid to evenly convex polyhedra and finite linear systems containing strict inequalities The book also analyzes evenly convex and quasiconvex functions from a conjugacy and duality perspective It discusses the applications of these functions in economics Written in an expository style the main concepts and basic results are illustrated with suitable examples and figures

Models and Measurement of Welfare and Inequality

Wolfgang Eichhorn, 2012-12-06 The literature on economic problems connected with measuring and modelling of welfare and inequality has grown rapidly within the last decade Since this literature is scattered throughout a great number of journals on economics economic theory econometrics and statistics it is difficult to get an adequate picture of the present state of the art Therefore books should appear from time to time which offer a representative cross section of the latest results of research on the subject This book offers such material It contains 54 articles by 84 authors from four of the five continents Each paper has been reviewed by two referees As a consequence the contributions of this book are revised versions or in many cases revised revisions of the original papers The book is divided into four parts Part I Measurement of Inequality and Poverty This part contains eleven papers on theory and empirical applications of inequality and or poverty measures Two contributions deal with among other things experimental findings on questions concerning the acceptance of distributional axioms Part II Taxation and Redistribution Distributional or rather redistributive aspects play an important role in Part II The topics of the 14 papers included in this part range from tax progressivity and redistribution allocative consequences of splitting under income taxation and connections between income tax and cost of living indices to merit goods and welfarism as well as to welfare aspects of tax reforms

Graphs and Combinatorial Optimization: from Theory to Applications

Claudio Gentile, Giuseppe Stecca, Paolo Ventura, 2021-03-01 This book highlights new and original contributions on Graph Theory and Combinatorial Optimization both from the theoretical point of view and from applications in all fields The book chapters describe models and methods based on graphs structural properties discrete optimization network optimization mixed integer programming heuristics meta heuristics math heuristics and exact methods as well as applications The book collects selected contributions from the CTW2020 international conference 18th Cologne Twente Workshop on Graphs and Combinatorial Optimization held online on September 14-16 2020 The conference was organized by IASI CNR with the contribution of University of Roma Tre University Roma Tor Vergata and CNRS LIX and with the support of AIRO It is addressed to researchers PhD students and practitioners in the fields of Graph Theory Discrete Mathematics Combinatorial Optimization and Operations Research

Handbook of Convex Geometry

Bozzano G Luisa, 2014-06-28 Handbook of Convex Geometry Volume A offers a survey of convex geometry and its many ramifications and relations with other areas of mathematics including convexity geometric inequalities and convex sets The selection first offers information on the history of convexity characterizations of convex sets and mixed volumes Topics include elementary convexity equality in the Aleksandrov Fenchel inequality mixed surface area measures characteristic properties of convex sets in analysis and differential geometry and extensions of the notion of a convex set The text then reviews the standard isoperimetric theorem and stability of geometric inequalities The manuscript takes a look at selected affine isoperimetric inequalities extremum problems for convex discs and polyhedra and rigidity Discussions focus on include infinitesimal and static rigidity related to surfaces isoperimetric problem for convex polyhedral bounds for the volume of a convex polyhedron curvature image

inequality Busemann intersection inequality and its relatives and Petty projection inequality The book then tackles geometric algorithms convexity and discrete optimization mathematical programming and convex geometry and the combinatorial aspects of convex polytopes The selection is a valuable source of data for mathematicians and researchers interested in convex geometry Mathematics from Leningrad to Austin, Volume 2 Rudolph A. Lorentz, 1997-07-15 The works of George G Lorentz spanning more than 60 years have played a significant role in the development and evolution of mathematical analysis The papers presented in this volume represent a selection of his best works along with commentary from his students and colleagues Linear Optimization and Extensions Dimitris Alevras, Manfred W. Padberg, 2012-12-06 Books on a technical topic like linear programming without exercises ignore the principal beneficiary of the endeavor of writing a book namely the student who learns best by doing course Books with exercises if they are challenging or at least to some extent so exercises of need a solutions manual so that students can have recourse to it when they need it Here we give solutions to all exercises and case studies of M Padberg s Linear Optimization and Extensions second edition Springer Verlag Berlin 1999 In addition we have included several new exercises and taken the opportunity to correct and change some of the exercises of the book Here and in the main text of the present volume the terms book text etc designate the second edition of Padberg s LPbook and the page and formula references refer to that edition as well All new and changed exercises are marked by a star in this volume The changes that we have made in the original exercises are inconsequential for the main part of the original text where several of the exercises especially in Chapter 9 are used on several occasions in the proof arguments None of the exercises that are used in the estimations etc have been changed *Linear Optimization and Extensions* Manfred Padberg, 2013-04-17 I was pleasantly surprised when I was asked by Springer Verlag to prepare a second edition of this volume on Linear Optimization and Extensions which not exactly contrary to my personal expectations has apparently been accepted reasonably well by the global optimization community My objective in putting this book together was originally and still is to detail the major algorithmic ideas in linear optimization that have evolved in the past fifty years or so and that have changed the historical optimization landscape in substantial ways both theoretically and computationally While I may have overlooked the importance of some very recent developments the work by Farid Alizadeh which generalizes linear programming to semi definite programming is perhaps a candidate for one of my omissions I think that major new breakthroughs on those two fronts that interest me theory and computation have not occurred since this book was published originally As a consequence I have restricted myself to a thorough re working of the original manuscript with the goal of making it more readable Of course I have taken this opportunity to correct a few Sch neitsfehler of the first edition and to add some illustrations The index to this volume has been extended substantially to permit a hurried reader a quicker glance at the wealth of topics that were covered nevertheless already in the first edition As was the case with the first edition Dr

Energy-Aware Memory Management for Embedded Multimedia Systems Florin Balasa, Dhiraj K.

Pradhan,2011-11-16 Energy Aware Memory Management for Embedded Multimedia Systems A Computer Aided Design Approach presents recent computer aided design CAD ideas that address memory management tasks particularly the optimization of energy consumption in the memory subsystem It explains how to efficiently implement CAD solutions including theoretical methods an

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