GENERALIZED MOMENT REPRESENTATIONS, BIORTHOGONAL POLYNOMIALS, AND PADÉ APPROXIMANTS

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By using the method of generalized moment representations and certain properties of biorthogonal polynomials, we establish new invariance properties of the Padé approximants.

1. Padé Approximants and Generalized Moment Representations

The method of Padé approximants is one of the most efficient and widely used methods for rational approximation of analytic functions. Padé approximants and their applications are studied in numerous papers (see, e.g., the bibliography in [1]).

Definition 1 [1, p. 311]. *Assume that a function* $f(z)$ *can be expanded in a power series of the form*

$$f(z) = \sum_{k=0}^{\infty} s_k z^k \tag{1}$$

in a neighborhood of the point $z = 0$. *The rational function*

$$[M/N]_f(z) = \frac{P_M(z)}{Q_N(z)}, \tag{2}$$

where $P_M(z)$ *and* $Q_N(z)$ *are algebraic polynomials of degree not higher than* M *and* N, *respectively, is called the Padé approximant of degree* $[M/N]$ *for the function* $f(z)$ *if* $f(z) - [M/N]_f(z) = O(z^{M+N+1})$ *for* $z \to 0$.

It was shown by Jacobi that the construction of the Padé approximants for functions defined by their power expansions (1) can be reduced to the solution of linear algebraic equations and, hence, approximants (2) can be represented as a ratio of determinants [1, p. 18]. In many cases, however, this approach is not efficient. If $f(z)$ is a Markov function, i.e., if it can be represented in the form of an integral

$$f(z) = \int_{\Delta} \frac{d\mu(t)}{1 - zt}, \tag{3}$$

where $\mu(t)$ is a nondecreasing function with infinitely many points of growth on a real interval Δ, then the construction of the Padé approximants of degree $[N - 1/N]$, $N \in \mathbf{N}$, for $f(z)$ can be reduced to the construction of polynomials orthogonal on Δ with weight $d\mu(t)$ [2, p. 34].

In 1981, Dzyadyk [3] suggested the method of generalized moment representations, which enables one to construct and investigate the Padé approximants of functions more general than (3).

Pad Approximants

Abdul-Majid Wazwaz

Pad Approximants:

Partial Differential Equations and Solitary Waves Theory Abdul-Majid Wazwaz,2010-05-28 Partial Differential Equations and Solitary Waves Theory is a self contained book divided into two parts Part I is a coherent survey bringing together newly developed methods for solving PDEs While some traditional techniques are presented this part does not require thorough understanding of abstract theories or compact concepts Well selected worked examples and exercises shall guide the reader through the text Part II provides an extensive exposition of the solitary waves theory This part handles nonlinear evolution equations by methods such as Hirota s bilinear method or the tanh coth method A self contained treatment is presented to discuss complete integrability of a wide class of nonlinear equations This part presents in an accessible manner a systematic presentation of solitons multi soliton solutions kinks peakons cuspons and compactons While the whole book can be used as a text for advanced undergraduate and graduate students in applied mathematics physics and engineering Part II will be most useful for graduate students and researchers in mathematics engineering and other related fields Dr Abdul Majid Wazwaz is a Professor of Mathematics at Saint Xavier University Chicago Illinois USA   Computational Analysis of Structured Media Simon Gluzman,Vladimir Mityushev,Wojciech Nawalaniec,2017-09-20 Computational Analysis of Structured Media presents a systematical approach to analytical formulae for the effective properties of deterministic and random composites Schwarz s method and functional equations yield for use in symbolic numeric computations relevant to the effective properties The work is primarily concerned with constructive topics of boundary value problems complex analysis and their applications to composites Symbolic numerical computations are widely used to deduce new formulae interesting for applied mathematicians and engineers The main line of presentation is the investigation of two phase 2D composites with non overlapping inclusions randomly embedded in matrices Computational methodology for main classes of problems in structured media Theory of Representative Volume Element Combines exact results Monte Carlo simulations and Resummation techniques under one umbrella Contains new analytical formulae obtained in the last ten years and it combines different asymptotic methods with the corresponding computer implementations   **Automata, Languages, and Programming** Magnús M. Halldórsson,Kazuo Iwama,Naoki Kobayashi,Bettina Speckmann,2015-06-19 The two volume set LNCS 9134 and LNCS 9135 constitutes the refereed proceedings of the 42nd International Colloquium on Automata Languages and Programming ICALP 2015 held in Kyoto Japan in July 2015 The 143 revised full papers presented were carefully reviewed and selected from 507 submissions The papers are organized in the following three tracks algorithms complexity and games logic semantics automata and theory of programming and foundations of networked computation models algorithms and information management   **Polygons, Polyominoes and Polycubes** A. J. Guttmann,2009-05-18 The problem of counting the number of self avoiding polygons on a square grid therbytheirperimeterortheirenclosedarea is aproblemthatis soeasytostate that at rst sight it seems surprising that it hasn t been solved It is however perhaps the simplest

member of a large class of such problems that have resisted all attempts at their exact solution These are all problems that are easy to state and look as if they should be solvable They include percolation in its various forms the Ising model of ferromagnetism polyomino enumeration Potts models and many others These models are of intrinsic interest to mathematicians and mathematical physicists but can also be applied to many other areas including economics the social sciences the biological sciences and even to traf c models It is the widespread applicab ity of these models to interesting phenomena that makes them so deserving of our attention Here however we restrict our attention to the mathematical aspects Here we are concerned with collecting together most of what is known about polygons and the closely related problems of polyominoes We describe what is known taking care to distinguish between what has been proved and what is c tainlytrue but has notbeenproved Theearlierchaptersfocusonwhatis knownand on why the problems have not been solved culminating in a proof of unsolvability in a certain sense The next chapters describe a range of numerical and theoretical methods and tools for extracting as much information about the problem as possible in some cases permittingexactconjecturesto be made   Nonlinear Numerical Methods and Rational Approximation II A. Cuyt,2012-12-06 These are the proceedings of the international conference on Nonlinear numerical methods and Rational approximation II organised by Annie Cuyt at the University of Antwerp Belgium 05 11 September 1993 It was held for the third time in Antwerp at the conference center of UIA after successful meetings in 1979 and 1987 and an almost yearly tradition since the early 70 s The following figures illustrate the growing number of participants and their geographical dissemination In 1993 the Belgian scientific committee consisted of A Bultheel Leuven A Cuyt Antwerp J Meinguet Louvain Ia Neuve and J P Thiran Namur The conference focused on the use of rational functions in different fields of Numer ical Analysis The invited speakers discussed Orthogonal polynomials D S Lu binsky Rational interpolation M Gutknecht Rational approximation E B Saff Pade approximation A Gonchar and Continued fractions W B Jones In contributed talks multivariate and multidimensional problems applications and implementations of each main topic were considered To each of the five main topics a separate conference day was devoted and a separate proceedings chapter compiled accordingly In this way the proceedings reflect the organisation of the talks at the conference Nonlinear numerical methods and rational approximation may be a nar row field for the outside world but it provides a vast playground for the chosen ones It can fascinate specialists from Moscow to South Africa from Boulder in Colorado and from sunny Florida to Zurich in Switzerland   *Padé Approximants* George Allen Baker,Peter Graves-Morris,1996-01-26 The first edition of this book was reviewed in 1982 as the most extensive treatment of Pade approximants actually available This second edition has been thoroughly updated with a substantial new chapter on multiseries approximants Applications to statistical mechanics and critical phenomena are extensively covered and there are newly extended sections devoted to circuit design matrix Pade approximation and computational methods This succinct and straightforward treatment will appeal to scientists engineers and mathematicians alike   Padé Approximants: Extensions

and applications George Allen Baker,P. R. Graves-Morris,1981   **Padé Approximants for Operators** Annie Cuyt,1984
     Applications Of Pade' Approximation Theory In Fluid Dynamics Amilcare Pozzi,1994-03-07 Although Pad presented his fundamental paper at the end of the last century the studies on Pad s approximants only became significant in the second part of this century Pad procedure is related to the theory of continued fractions and some convergence theorems can be expressed only in terms of continued fractions Further Pad approximants have some advantages of practical applicability with respect to the continued fraction theory Moreover as Chisholm notes a given power series determines a set of approximants which are usually unique whereas there are many ways of writing an associated continued fraction The principal advantage of Pad approximants with respect to the generating Taylor series is that they provide an extension beyond the interval of convergence of the series Pad approximants can be applied in many parts of fluid dynamics both in steady and in nonsteady flows both in incompressible and in compressible regimes This book is divided into four parts The first one deals with the properties of the Pad approximants that are useful for the applications and illustrates with the aid of diagrams and tables the effectiveness of this technique in the field of applied mathematics The second part recalls the basic equations of fluid dynamics those associated with the names of Navier Stokes Euler and Prandtl and gives a quick derivation of them from the general balance equation The third shows eight examples of the application of Pad approximants to steady flows also taking into account the influence of the coupling of heat conduction in the body along which a fluid flows with conduction and convection in the fluid itself The fourth part considers two examples of the application of Pad approximants to unsteady flows   **Nuclear Science Abstracts** ,1972   *Theoretical High Energy Physics* Roger Migneron,Vic Elias,Dennis Gerard Creaser McKeon,2001-11-30 MRST 2001 the 23rd of a series of meetings in theoretical high energy physics that normally rotate between McGill University The University of Toronto The University of Rochester and Syracuse University honors the memory of Roger Migneron a frequent participant in past MRST meetings and a strong contributor to elementary particle physics in Canada Two special sessions present exciting advances in theoretical high energy physics by several outstanding physicists Topics include gravity geometry B physics quarks gluons and mesons field theory as well as branes strings and things   Physics Briefs ,1988   Padé Approximants George Allen Baker,Peter Graves-Morris,1981
     History of Continued Fractions and Padé Approximants Claude Brezinski,2012-12-06 The history of continued fractions is certainly one of the longest among those of mathematical concepts since it begins with Euclid s algorithm for the great est common divisor at least three centuries B C As it is often the case and like Monsieur Jourdain in Moliere s Ie bourgeois gentilhomme who was speak ing in prose though he did not know he was doing so continued fractions were used for many centuries before their real discovery The history of continued fractions and Pade approximants is also quite im portant since they played a leading role in the development of some branches of mathematics For example they were the basis for the proof of the tran scendence of 11 in 1882 an open problem for more than two thousand years and also for our modern

spectral theory of operators Actually they still are of great interest in many fields of pure and applied mathematics and in numerical analysis where they provide computer approximations to special functions and are connected to some convergence acceleration methods Con tinued fractions are also used in number theory computer science automata electronics etc

Expanded Abstracts with Biographies ,2001   *Numerical Mathematics* ,2006   **Encyclopedia of Mathematics and Its Applications** ,1981   Advances in Matrix Theory and Its Applications Erxiong Jiang,Chuan-Long Wang,2008

Searching in RLIN II. Jonathan Lavigne,1984   Journal of the Institution of Engineers (India). Electrical Engineering Division ,1988

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Table of Contents Pad Approximants

1. Understanding the eBook Pad Approximants
    - The Rise of Digital Reading Pad Approximants
    - Advantages of eBooks Over Traditional Books
2. Identifying Pad Approximants
    - Exploring Different Genres
    - Considering Fiction vs. Non-Fiction
    - Determining Your Reading Goals
3. Choosing the Right eBook Platform
    - Popular eBook Platforms
    - Features to Look for in an Pad Approximants
    - User-Friendly Interface
4. Exploring eBook Recommendations from Pad Approximants
    - Personalized Recommendations

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