

# AUTOMATIC SEQUENCES

Theory, Applications, Generalizations

JEAN-PAUL ALLOUCHE & JEFFREY SHALLIT

## AUTOMATIC SEQUENCES

ALLOUCHE  
& SHALLIT

Uniting dozens of seemingly disparate results from different fields, this book combines concepts from mathematics and computer science to present the first integrated treatment of sequences generated by "finite automata."

The authors apply the theory to the study of automatic sequences and their generalizations, such as Sierpinski words and  $k$ - $1$ -regular sequences. And further, they provide applications to number theory (particularly to formal power series and transcendence in finite characteristics), physics, computer graphics, and music.

Starting from first principles wherever feasible, basic results from combinatorics on words, numeration systems, and models of computation are discussed. Thus this book is suitable for graduate students or advanced undergraduates, as well as for mature researchers wishing to know more about this fascinating subject.

Jean-Paul Allouche is Directeur de Recherche at CNRS, UJL, CReS. He has written some 40 papers in number theory and combinatorics on words. He is on the editorial board of *Advances in Applied Mathematics* and on the scientific committee of the *Journal de Théorie des Nombres de Bordeaux*.

Jeffrey Shallit is Professor of Computer Science at the University of Waterloo. He has written 60 articles on number theory, algorithms, formal languages, combinatorics on words, computer graphics, history of mathematics, algebra and automata theory. He is the editor-in-chief of the *Journal of Integer Sequences* and co-author of *Algorithmic Number Theory*.

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# Automatic Sequences

**A Gutmann**



## **Automatic Sequences:**

*Automatic Sequences* Jean-Paul Allouche, Jeffrey Shallit, 2003-07-21 Uniting dozens of seemingly disparate results from different fields this book combines concepts from mathematics and computer science to present the first integrated treatment of sequences generated by finite automata The authors apply the theory to the study of automatic sequences and their generalizations such as Sturmian words and  $k$  regular sequences And further they provide applications to number theory particularly to formal power series and transcendence in finite characteristic physics computer graphics and music Starting from first principles wherever feasible basic results from combinatorics on words numeration systems and models of computation are discussed Thus this book is suitable for graduate students or advanced undergraduates as well as for mature researchers wishing to know more about this fascinating subject Results are presented from first principles wherever feasible and the book is supplemented by a collection of 460 exercises 85 open problems and over 1600 citations to the literature

*Automatic Sequences* Friedrich von Haeseler, 2003 Automatic sequences are sequences which are produced by a finite automaton Although they are not random they may look as being random This text deals with different aspects of automatic sequences including a general introduction and the algebraic approach to automatic sequences     **Sequences, Groups, and Number Theory** Valérie Berthé, Michel Rigo, 2018-04-09 This collaborative book presents recent trends on the study of sequences including combinatorics on words and symbolic dynamics and new interdisciplinary links to group theory and number theory Other chapters branch out from those areas into subfields of theoretical computer science such as complexity theory and theory of automata The book is built around four general themes number theory and sequences word combinatorics normal numbers and group theory Those topics are rounded out by investigations into automatic and regular sequences tilings and theory of computation discrete dynamical systems ergodic theory numeration systems automaton semigroups and amenable groups This volume is intended for use by graduate students or research mathematicians as well as computer scientists who are working in automata theory and formal language theory With its organization around unified themes it would also be appropriate as a supplemental text for graduate level courses     **Language and Automata Theory and Applications** Adrian-Horia Dediu, Carlos Martín-Vide, Bianca Truthe, 2013-03-15 This book constitutes the refereed proceedings of the 7th International Conference on Language and Automata Theory and Applications LATA 2013 held in Bilbao Spain in April 2013 The 45 revised full papers presented together with 5 invited talks were carefully reviewed and selected from 97 initial submissions The volume features contributions from both classical theory fields and application areas bioinformatics systems biology language technology artificial intelligence etc Among the topics covered are algebraic language theory algorithms for semi structured data mining algorithms on automata and words automata and logic automata for system analysis and program verification automata concurrency and Petri nets automatic structures cellular automata combinatorics on words computability computational complexity computational linguistics data and image compression

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*Language and Automata Theory and Applications* Alberto Leporati, Carlos Martín-Vide, Dana Shapira, Claudio Zandron, 2020-02-25 This book constitutes the proceedings of the 14th International Conference on Language and Automata Theory and Applications LATA 2020 which was planned to be held in Milan Italy in March 2020 Due to the corona pandemic the actual conference was postponed and will be held together with LATA 2021 The 26 full papers presented in this volume were carefully reviewed and selected from 59 submissions They were organized in topical sections named algebraic structures automata complexity grammars languages trees and graphs and words and codes The book also contains 6 invited papers in full paper length

Developments in Language Theory Nelma Moreira, Rogério Reis, 2021-08-06 This book constitutes the proceedings of the 25th International Conference on Developments in Language Theory DLT 2021 which was held in Porto Portugal during August 16 20 2021 The conference took place in an hybrid format with both in person and online participation The 27 full papers included in these proceedings were carefully reviewed and selected from 48 submissions The DLT conference series provides a forum for presenting current developments in formal languages and automata Its scope is very general and includes among others the following topics and areas grammars acceptors and transducers for words trees and graphs algebraic theories of automata algorithmic combinatorial and algebraic properties of words and languages variable length codes symbolic dynamics cellular automata polyominoes and multidimensional patterns decidability questions image manipulation and compression efficient text algorithms relationships to cryptography concurrency complexity theory and logic bio inspired computing quantum computing The book also includes 3 invited talks in full paper length

**Logic and Program Semantics** Robert L. Constable, Alexandra Silva, 2012-04-26 This Festschrift volume is published in honor of Dexter Kozen on the occasion of his 60th birthday Dexter Kozen has been a leader in the development of Kleene Algebras KAs The contributions in this volume reflect the breadth of his work and influence The volume includes 19 full papers related to Dexter Kozen's research They deal with coalgebraic methods congruence closure the completeness of various programming logics decision procedure for logics alternation algorithms and complexity and programming languages and program analysis The second part of this volume includes laudations from several collaborators

students and friends including the members of his current band

### **Uniform Distribution and Quasi-Monte Carlo**

**Methods** Peter Kritzer, Harald Niederreiter, Friedrich Pillichshammer, Arne Winterhof, 2014-06-23 This book is summarizing the results of the workshop Uniform Distribution and Quasi Monte Carlo Methods of the RICAM Special Semester on Applications of Algebra and Number Theory in October 2013 The survey articles in this book focus on number theoretic point constructions uniform distribution theory and quasi Monte Carlo methods As deterministic versions of the Monte Carlo method quasi Monte Carlo rules enjoy increasing popularity with many fruitful applications in mathematical practice as for example in finance computer graphics and biology The goal of this book is to give an overview of recent developments in uniform distribution theory quasi Monte Carlo methods and their applications presented by leading experts in these vivid fields of research

### **Sequences and Their Applications**

T. Helleseth, P.V. Kumar, 2002 Pseudorandom sequences have widespread applications for instance in spread spectrum code division multiple access optical and ultrawide band communication systems as well as in ranging systems global positioning systems circuit testing and stream ciphers Such sequences also have strong ties to error correcting codes This volume contains survey and research papers on sequences and their applications It brings together leading experts from discrete mathematics computer science and communications engineering and helps to bridge advances in these different areas Papers in this volume discuss the theory of sequences and their applications in cryptography coding theory communications systems numerical computation and computer simulation

### Automatic Sequences and Decidable Properties Daniel Goc, 2013

In 1912 Axel Thue sparked the study of combinatorics on words when he showed that the Thue Morse sequence contains no overlaps that is factors of the form  $ayaya$  Since then many interesting properties of sequences began to be discovered and studied In this thesis we consider a class of infinite sequences generated by automata called the  $k$  automatic sequences In particular we present a logical theory in which many properties of  $k$  automatic sequences can be expressed as predicates and we show that such predicates are decidable Our main contribution is the implementation of a theorem prover capable of practically characterizing many commonly sought after properties of  $k$  automatic sequences We showcase a panoply of results achieved using our method We give new explicit descriptions of the recurrence and appearance functions of a list of well known  $k$  automatic sequences We define a related function called the condensation function and give explicit descriptions for it as well We reaffirm known results on the critical exponent of some sequences and determine it for others where it was previously unknown On the more theoretical side we show that the subword complexity  $p_n$  of  $k$  automatic sequences is  $k$  synchronized i.e. the language of pairs  $(n, p_n)$  expressed in base  $k$  is accepted by an automaton Furthermore we prove that the Lyndon factorization of  $k$  automatic sequences is also  $k$  automatic and explicitly compute the factorization for several sequences Finally we show that while the number of unbordered factors of length  $n$  is not  $k$  synchronized it is  $k$  regular

### **A Functional Description of the Edvac**

**[an Automatically-sequence Serial Binary Electronic Digital Computer** Moore School of Electrical Engineering, 1949

**STACS 89** B. Monien, Robert Cori, 1989 This volume contains the presentations of the Sixth Symposium on Theoretical Aspects of Computer Science STACS 89 held at the University of Paderborn February 16 18 1989 In addition to papers presented in the regular program the volume contains abstracts of software systems demonstrations which were included in this conference series in order to show applications of research results in theoretical computer science The papers are grouped into the following thematic sections computational geometry automata theory and formal languages semantics of programming languages parallel algorithms graph algorithms complexity structures fault tolerance completeness distributed computing and concurrency *Journal Für Die Reine und Angewandte Mathematik* August Leopold Crelle, Carl Wilhelm Borchardt, Leopold Kronecker, Lazarus Fuchs, Kurt Hensel, Helmut Hasse, Friedrich Schottky, 2003 **The Monist**, 1903 Vols 2 and 5 include appendices Mechanical Engineering American Society of Mechanical Engineers, 1947 The Logical Approach to Automatic Sequences Jeffrey Shallit, 2022-09-29 Automatic sequences are sequences over a finite alphabet generated by a finite state machine This book presents a novel viewpoint on automatic sequences and more generally on combinatorics on words by introducing a decision method through which many new results in combinatorics and number theory can be automatically proved or disproved with little or no human intervention This approach to proving theorems is extremely powerful allowing long and error prone case based arguments to be replaced by simple computations Readers will learn how to phrase their desired results in first order logic using free software to automate the computation process Results that normally require multipage proofs can emerge in milliseconds allowing users to engage with mathematical questions that would otherwise be difficult to solve With more than 150 exercises included this text is an ideal resource for researchers graduate students and advanced undergraduates studying combinatorics sequences and number theory **Sequences, Discrepancies and Applications** Michael Drmota, Robert F. Tichy, 1997-03-20 The main purpose of this book is to give an overview of the developments during the last 20 years in the theory of uniformly distributed sequences The authors focus on various aspects such as special sequences metric theory geometric concepts of discrepancy irregularities of distribution continuous uniform distribution and uniform distribution in discrete spaces Specific applications are presented in detail numerical integration spherical designs random number generation and mathematical finance Furthermore over 1000 references are collected and discussed While written in the style of a research monograph the book is readable with basic knowledge in analysis number theory and measure theory **Western Metalworking**, 1948 **Annual Symposium on Theoretical Aspects of Computer Science**, 2006 **Principles of Mental Physiology** William Benjamin Carpenter, 1875 Psychophysiologie

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web dec 9 2018 use the smart goal setting model to set short and long term goals that are specific measurable attainable realistic and time bound a short term goal might involve getting proficient at a certain type of software or producing more documents each week in the smart model mastering x software by june 1 would be the specific goal

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to help you succeed professionally expand your professional network improve hard skills related to your industry develop a relationship with a mentor earn a new professional certification expand your business into a new

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