

Chapter 1

REPETITIONS

1.1 WORDS AND LANGUAGES

Our first topic is repetitions of words. This is the oldest topic studied in formal language theory, going back to the work of Axel Thue at the beginning of this century. Thue's results have been rediscovered many times in various disguises. Before discussing the results themselves, we have to introduce some notions and terminology needed throughout this book.

An *alphabet* is a finite nonempty set. The elements of an alphabet Σ are called *letters* or *symbols*. A *word* over an alphabet Σ is a finite string consisting of zero or more letters of Σ , whereby the same letter may occur several times. The string consisting of zero letters is called the *empty word*, written λ . Thus, λ , 0, 1, 010, 1111 are words over the alphabet $\Sigma = \{0, 1\}$. The set of all words (resp. all nonempty words) over an alphabet Σ is denoted by Σ^* (resp. Σ^+). The set Σ^* is infinite for any Σ . Algebraically, Σ^* and Σ^+ are the free monoid and free semigroup generated by Σ .

The reader should keep in mind that the basic set Σ , its elements and strings of its elements could equally well be called a vocabulary, words and sentences, respectively. This would reflect an approach aiming at applications mainly in the field of natural languages. In this book, we stick to the standard mathematical terminology introduced above.

If x and y are words over an alphabet Σ , then so is their concatenation xy . Concatenation is an associative operation, and the empty word is an identity with respect to concatenation: $(x)y = \lambda x = x$ holds for all words x . For a word x and a natural number i , the notation x^i means the word obtained by concatenating i copies of the word x . By definition, x^0 is the empty word λ .

The *length* of a word x , in symbols $|x|$, is the number of letters in x when each letter is counted as many times as it occurs. Again by definition, $|\lambda| = 0$. The length function possesses some of the formal properties of logarithm:

$$|xy| = |x| + |y|, \quad |x^i| = i|x|,$$

for any words x and y and integers $i \geq 0$.

Jewels Formal Lang

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The Book of L G. Rozenberg, A. Salomaa, 2012-12-06 This book is dedicated to Aristid Lindenmayer on the occasion of his 60th birthday on November 17 1985 Contributions range from mathematics and theoretical computer science to biology Aristid Lindenmayer introduced language theoretic models for developmental biology in 1968 Since then the models have been customarily referred to as L systems Lindenmayer's invention turned out to be one of the most beautiful examples of interdisciplinary science work in one area developmental biology induces most fruitful ideas in other areas theory of formal languages and automata and formal power series As evident from the articles and references in this book the interest in L systems is continuously growing For newcomers the first contact with L systems usually happens via the most basic class of L systems namely DOL systems Here 0 stands for zero context between developing cells It has been a major typographical problem that printers are unable to distinguish between 0 zero and 0 oh Thus DOL was almost always printed with oh rather than zero and also pronounced that way However this misunderstanding turned out to be very fortunate The wrong spelling DOL of DOL could be read in the suggestive way DO L Indeed hundreds of researchers have followed this suggestion Some of them appear as contributors to this book Of the many who could not contribute we in particular regret the absence of A Ehrenfeucht G Herman and H A Maurer whose influence in the theory of L systems has been most significant

Biolinguistic Investigations and the Formal Language Hierarchy Juan Uriagereka, 2018-06-14 This volume collects some of Juan Uriagereka's previously published pieces and presentations on biolinguistics in recent years in one comprehensive volume The book's introduction lays the foundation for the field of biolinguistics which looks to integrate concepts from the natural sciences in the analysis of natural language situating the discussion within the minimalist framework The volume then highlights eight of the author's key papers from the literature some co-authored representative of both the architectural and evolutionary considerations to be taken into account within biolinguistic research The book culminates in a final chapter showcasing the body of work being done on biolinguistics within the research program at the University of Maryland and their implications for interdisciplinary research and future directions for the field This volume is essential reading for students and scholars interested in the interface between language and the natural sciences including linguistics syntax biology archaeology and anthropology

VLSI Design Norman G. Einspruch, 2014-12-01 VLSI Electronics Microstructure Science Volume 14 VLSI Design presents a comprehensive exposition and assessment of the developments and trends in VLSI Very Large Scale Integration electronics This volume covers topics that range from microscopic aspects of materials behavior and device performance to the comprehension of VLSI in systems applications Each article is prepared by a recognized authority The subjects discussed in this book include VLSI processor design methodology the RISC Reduced Instruction Set Computer the VLSI testing program silicon compilers for VLSI and specialized silicon compiler and programmable chip for language recognition Scientists engineers researchers device designers and systems architects will

find the book very useful **LATIN 2002: Theoretical Informatics** Sergio Rajsbaum, 2003-07-31 This book constitutes the refereed proceedings of the 5th International Symposium Latin American Theoretical Informatics LATIN 2002 held in Cancun Mexico in April 2002 The 44 revised full papers presented together with a tutorial and 7 abstracts of invited contributions were carefully reviewed and selected from a total of 104 submissions The papers presented are devoted to a broad range of topics from theoretical computer science and mathematical foundations with a certain focus on algorithmics and computations related to discrete structures Developments in Language Theory Clelia De Felice, Antonio Restivo, 2005-06-20 DLT 2005 was the 9th Conference on Developments in Language Theory **The Book of L** Grzegorz Rozenberg, 1986 **Algorithmik** David Harel, Yishai Feldman, 2006-10-19 Algorithmen sind der Kern der Informatik und der Mathematik da jede Nutzung eines Computers erst durch Rechenverfahren überhaupt möglich wird In diesem Buch das in der englischen Originalausgabe schon lange ein Bestseller ist gibt der Autor und sein Co Autor umfassend und didaktisch geschickt Auskunft zu allen Fragen rund um das Thema Algorithmen so z B zu Themen wie Berechenbarkeit Korrektheit und Effizienz von Algorithmen zu Programmiertechniken und auch das aktuelle Thema Quantenrechnen wird behandelt Das Buch kann als Grundlage eines einsemestrigen Einführungskurses in die Informatik dienen oder als allgemeine Informatik Einführung in den Naturwissenschaften der Mathematik oder im Ingenieurwesen *Concise Descriptions of Context-free Languages* Johnny Gregory Martin, 1990 *VLSI Electronics: VLSI design* Norman G. Einspruch, 1981 **National Union Catalog, 1981** ,1982 **Technolingualism** James Pfrehm, 2018-01-25 Since the earliest days of our species technology and language have evolved in parallel This book examines the processes and products of this age old relationship a phenomenon we are calling technolingualism the mutually influential relationship between language and technology One the one hand as humans advance technology to master control and change the world around us our language adapts More sophisticated social cultural practices give rise to new patterns of linguistic communication Language changes in its vocabulary structures social conventions and ideologies Conversely and this side of the story has been widely overlooked the unique features of human language can influence a technology's physical forms and technical processes Technolingualism explores the fascinating ways past and present by which language and technology have informed each other's development The book reveals important corollaries about the universal nature of language and most importantly what it means to be human From our first babbling noises to the ends of our lives we are innately attuned to the technologies around us and our language reflects this We are all of us technolinguals *Algoritmi* David Harel, Yishai Feldman, 2008-08-17 Un'eccellente introduzione agli algoritmi alla loro struttura a come modificano i dati alla computabilità e alla complessità il libro scritto in una forma allo stesso tempo elegante e schietto che fa sì che possa essere considerato sia un valido testo per un corso introduttivo di Informatica sia un tesoro da custodire per i programmatori provetti e i progettisti di software *National Union Catalog* , Includes entries for maps and atlases **Developments in Language Theory** Zoltán Ésik, Zoltán Fülöp, 2003-08-03 The

refereed proceedings of the 7th International Conference on Developments in Language Theory DLT 2003 held in Szeged Hungary in July 2003 The 27 revised full papers presented together with 7 invited papers were carefully reviewed and selected from 57 submissions All current aspects in language theory are addressed in particular grammars acceptors and transducers for strings trees graphs arrays etc algebraic theories for automata and languages combinatorial properties of words and languages formal power series decision problems efficient algorithms for automata and languages and relations to complexity theory and logic picture description and analysis DNA computing quantum computing cryptography and concurrency

Implementation and Application of Automata Oscar H. Ibarra, 2006-08-10 This book constitutes the refereed proceedings of the 11th International Conference on Implementation and Application of Automata CIAA 2006 held in Taipei Taiwan in August 2006 The 22 revised full papers and 7 revised poster papers presented together with the extended abstracts of 3 invited lectures were carefully reviewed and selected from 76 submissions The papers cover various topics in the theory implementation and applications of automata and related structures

Mads Lange's Forgotten Treasures Peter Bloch, 2021-02-01 Mads Johansen Lange 1807 1856 was the most influential person that made Bali prosper during the mid 19th century In order to receive favorable treatment and procure lucrative trade deals he presented the kings of Bali with luxury goods His philosophy was to unite and share rather than divide and conquer so he treated all his relationships equally within the social political system of the time Lange strived to have peace maintained in Bali for his business to succeed and for the welfare of the inhabitants The prosperity is evident in the luxury goods that he presented to his contacts from valuable daggers with gold and precious gems to elaborate temple sculptures to fancy carved cabinets Lange branded these gifts with his name many with an image of his face or important scenes from his life Portrait figures done in an unusual and animated style illustrate important events from befriending royalty to playful interactions with his wives to negotiating peace treaties between the Balinese and the Dutch Those who are closely or remotely familiar with Lange's role in Balinese history will be fascinated by these artifacts as they increase the interest and understanding of him as a human being These gifts remained hidden in palaces temples and caves across the island for nearly 200 years This unique collection was made possible through the untiring efforts of a fellow Dane Peter Bloch

Mathematical Reviews ,1986 [Computing Newsletter for Schools of Business](#) ,1982

Rewriting Techniques and Applications Aart Middeldorp, 2003-06-29 This book constitutes the refereed proceedings of the 12th International Conference on Rewriting Techniques and Applications RTA 2001 held in Utrecht The Netherlands in May 2001 The 23 revised full papers presented together with two system descriptions were carefully reviewed and selected from 55 submissions All current aspects of rewriting are addressed

Annales Academiae Scientiarum Fennicae. Series A. I, Mathematica ,1986

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