

## PERSONAL INFORMATION

Massimiliano Goldwurm  
Born in Milan in 1958

PRESENT POSITION  
(FROM 01/10/2009)

Full professor,  
in Computer Science  
Università degli Studi di Milano

from 2015 at the Department of Mathematics  
Via Saldini 50, Milano

## WORK EXPERIENCE

From October 2009 to May  
2012

Head of Department  
of Information Science  
Università degli Studi di Milano

From 01/10/2006 to  
30/09/2009

“Professore Straordinario”  
Università degli Studi di Milano  
(Settore scientifico-disciplinare INF/01 - Informatica)

From 1/11/1992 to 30/09/2006

Associate professor  
in Computer Science  
Università degli Studi di Milano  
(Settore K05B - Informatica)

From 1/04/1990 to 31/10/1992

Researcher  
in Computer Science  
Università degli Studi di Milano

## EDUCATION AND TRAINING

From 1984 to 1987

PhD in Computer Science  
Università degli Studi di Milano,  
Thesis “Formal series methods in algorithms analysis for problems on languages”  
Relatori: Prof. Alberto Bertoni (Unimi), Prof. Aldo de Luca (Univ. “La Sapienza Roma”), Prof. Emo  
Welzl (Freie Universität Berlin).

In 1982

Degree in Mathematics  
Università degli Studi di Milano

## RESEARCH

His research interests are in the area of computational complexity, automata theory and formal languages. In particular he has considered generating functions and probabilistic methods as investigation tools. The main results of his research concern the complexity of counting problems, the theory of trace languages and in particular the analysis of algorithms for membership problems, timed automata, the random generation of combinatorial structures and, recently, the analysis of pattern statistics and the complexity of clustering problems.

The main problem in pattern statistics is the analysis of the frequency of patterns in a text generated at random according to a probabilistic model. The contribution of this research concerns the limit distributions of pattern statistics in rational probabilistic models that extend the traditional Markovian models (papers [A14,A15,A16,A17] in the publication list of the present CV).

Clustering problems consist of determining a partition of a set of points in  $\mathbb{R}^d$  that minimizes the sum of distances of the points from the corresponding centroid. Specific results concern the NP-hardness of the problem assuming particular constraints on the cardinality of the sets or, vice-versa, the existence of efficient algorithms in some cases (for instance in the plane) [A24,A23,A22,C20,C19].

Another line of research concerns the classification of bidimensional languages and in particular the properties of the family of tiling-recognizable languages. Here the main contribution is a characterization of the unary versions of these languages in terms of computational complexity [A20, C16]. Finally, another subject considered in his recent research concerns the membership problem for subclasses of rational trace languages; in this case the main results concern the conditions that guarantee the existence of linear time algorithms for the problem [A21,C17]. This subject is also motivated by the study of parallelism for program compilers.

## PUBLICATIONS

## Journal papers

- [A24] M. Goldwurm, J. Lin, F. Saccà, *On the complexity of clustering with relaxed size constraints in fixed dimension*, **Theoretical Computer Science**, vol. 717 (2018), 37-46.
- [A23] J. Lin, A. Bertoni, M. Goldwurm, *Exact algorithms for size constrained 2-Clustering in the plane*, **Theoretical Computer Science**, vol. 629 (2016), 80-95.
- [A22] A. Bertoni, M. Goldwurm, J. Lin, F. Saccà, *Size constrained distance clustering: separation properties and some complexity results*, **Fundamenta Informaticae**, vol. 115 (2012), 125-139.
- [A21] L. Breveglieri, S. Crespi Reghizzi, M. Goldwurm, *Efficient recognition of trace languages defined by repeat-until loops*, **Information and Computation**, vol. 208 (8), 2010, 969-981.
- [A20] A. Bertoni, M. Goldwurm, V. Lonati, *The complexity of unary tiling recognizable picture languages: nondeterministic and unambiguous cases*, **Fundamenta Informaticae**, vol. 91 (2), 2009, 231-249.
- [A19] I. Cattinelli, M. Goldwurm, N.A. Borghese, *Interacting with an artificial partner: modeling the role of emotional aspects*, **Biological Cybernetics**, vol. 99, 2008, 473-489.
- [A18] M. Goldwurm, R. Radicioni, *Probabilistic models for pattern statistics*, **RAIRO Theoretical Informatics and Applications**, vol. 40, 2006, 207-225.
- [A17] M. Goldwurm, V. Lonati, *Pattern statistics and Vandermonde matrices*, **Theoretical Computer Science**, vol. 356 (1-2), 2006, 153-169.
- [A16] A. Bertoni, C. Choffrut, M. Goldwurm, V. Lonati, *Local limit properties for pattern statistics and rational models*, **Theory of Computing Systems**, vol. 39 (1), 2006, 209-235.
- [A15] D. de Falco, M. Goldwurm, V. Lonati, *Frequency of symbol occurrences in bicomponent stochastic models*, **Theoretical Computer Science**, vol. 327 (3), 2004, 269-300.
- [A14] A. Bertoni, C. Choffrut, M. Goldwurm, V. Lonati, *On the number of occurrences of a symbol in words of regular languages*, **Theoretical Computer Science**, vol. 302 (2003), 431-456.
- [A13] A. Bertoni, M. Goldwurm, M. Santini, *Random generation for finitely ambiguous context-free languages*, **RAIRO Theoretical Informatics and Applications**, vol. 35 (2001), 499-512.
- [A12] M. Goldwurm, M. Santini, *Cliques polynomials have a unique root of smallest modulus*, **Information Processing Letters**, vol. 75 (2000), 127-132.
- [A11] C. Choffrut, M. Goldwurm, *Timed automata with periodic clock constraints*, **Journal of Automata, Languages and Combinatorics**, vol. 5 (2000), 371-403.
- [A10] C. Choffrut, M. Goldwurm, *Determinants and Moebius functions in trace monoids*, **Discrete Mathematics** vol.194 (1999), 239-247.
- [A9] A. Avellone, M. Goldwurm, *Analysis of algorithms for the recognition of rational and context-free trace languages*, **RAIRO Theoretical Informatics and Applications**, vol. 32 (1998), 141-152.
- [A8] M. Goldwurm, *Random generation of words in an algebraic language in linear binary space*, **Information Processing Letters** vol. 54 (1995), 229-233.
- [A7] C. Choffrut, M. Goldwurm, *Rational transductions and complexity of counting problems*, **Mathematical Systems Theory** vol. 28 (1995), 437-450.
- [A6] A. Bertoni, M. Goldwurm, *On ranking 1-way finitely ambiguous NL languages and  $\#P_1$ -complete census functions*, **RAIRO Theoretical Informatics and Applications** vol.27 (1993), 135-148.
- [A5] M. Goldwurm, *Probabilistic estimation of the number of prefixes of a trace*, **Theoretical Computer Science** vol. 92 (1992), 249-268.
- [A4] A. Bertoni, D. Bruschi, M. Goldwurm, *Ranking and formal power series*, **Theoretical Computer Science** vol. 79 (1991), 25-35;
- [A3] A. Bertoni, M. Goldwurm, N. Sabadini, *The complexity of computing the number of strings of given length in context-free languages*, **Theoretical Computer Science** vol. 86 (1991), 325-342.
- [A2] M. Goldwurm, *Some limit distributions in analysis of algorithms for problems on trace languages*, **International Journal of Foundations of Computer Science** vol. 1 n.3 (1990), 265-276.
- [A1] A. Bertoni, M. Goldwurm, P. Massazza, *Counting problems and algebraic formal power series in noncommuting variables*, **Information Processing Letters** vol. 34 (1990), 117-121.

## Paper in volume

- [B1] A. Bertoni, M. Goldwurm, G. Mauri and N. Sabadini, *Counting techniques for inclusion, equivalence and membership problems*, Capitolo n. 5 in **The book of traces**, V.Diekert e G.Rozenberg editors, World Scientific Publishing, 131-164, 1995.

## Peer-reviewed conference papers

- [C21] M. Goldwurm, L. Lin, M. Vignati, *A local limit property for pattern statistics in bicomponent stochastic models*, **Proceedings 20<sup>th</sup> DCFS**, International Conference on Descriptive Complexity of Formal Systems, Lecture Notes in Computer Science n.10952, Springer (2018), 114-125.
- [C20] M. Goldwurm, L. Lin, F. Saccà, *On the complexity of clustering with relaxed size constraints*, **Proceedings 11<sup>th</sup> AAIM**, International Conference on Algorithmic Aspects in Information and Management, Lecture Notes in Computer Science n.9778, Springer-Verlag (2016), 26-38.
- [C19] A. Bertoni, M. Goldwurm, L. Lin, *Exact algorithms for 2-clustering with size-constraints in the Euclidean plane*, **Proceedings SOFSEM 2015**, 41<sup>st</sup> International Conference on Current Trends in Theory and Practice of Computer Science, Pec pod Sněžkou (Czech Republic), Lecture Notes in Computer Science n.8939, Springer-Verlag (2015), 128-139.

- [C18] A. Bertoni, M. Goldwurm, L. Lin, L. Pini, *Size-constrained 2-clustering in the plane with Manhattan distance*, **Proceedings of the 15th ICTCS**, Italian Conference on Theoretical Computer Science, Perugia, September 2014, <http://ceur-ws.org/Vol-1231/>, pp. 33-44, 2014.
- [C17] L. Breveglieri, S. Crespi Reghizzi, M. Goldwurm, *Efficient recognition of trace languages defined by repeat-until loops*, International Conference **WORDS 2009**, Salerno, 14-18 Settembre 2009.
- [C16] A. Bertoni, M. Goldwurm, V. Lonati, *On the complexity of unary tiling-recognizable picture languages*, **Proceedings STACS 2007**, 24<sup>th</sup> Symposium on Theoretical Aspects of Computer Science, Lecture Notes in Computer Science n.4393, Springer-Verlag (2007), 381-392.
- [C15] M. Goldwurm, R. Radicioni, *Average value and variance of pattern statistics in rational models*, **Proceedings CIAA 2007**, 12<sup>th</sup> International Conference on Implementation and Applications of Automata, Lecture Notes in Computer Science n. 4783, Springer-Verlag (2007), 62-72.
- [C14] M. Goldwurm, V. Lonati, *Pattern occurrences in multicomponent models*, **Proceedings STACS 2005**, 22<sup>nd</sup> Symposium on Theoretical Aspects of Computer Science, V. Diekert and B. Durand Editors, Lecture Notes in Computer Science n. 3404, Springer-Verlag (2005), 680-692.
- [C13] C. Choffrut, M. Goldwurm, V. Lonati, *On the maximum coefficients of rational formal series in commuting variables*, **Proceedings DLT 2004**, 8<sup>th</sup> International Conference Developments in Language Theory, Auckland (New Zealand), December 2004, C.S. Calude, E. Calude and M.J. Dinneen Editors, Lecture Notes in Computer Science n. 3340, Springer (2004), 114-126.
- [C12] A. Bertoni, C. Choffrut, M. Goldwurm, V. Lonati, *Local limit distributions in pattern statistics: beyond the Markovian models*, **Proceedings STACS 2004**, 21<sup>st</sup> Symposium on Theoretical Aspects of Computer Science, Montpellier (France), March 2004, V. Diekert and M. Habib Editors, Lecture Notes in Computer Science n. 2996, Springer-Verlag (2004), 117-128 .
- [C11] D. de Falco, M. Goldwurm, V. Lonati, *Pattern statistics in bicomponent stochastic models*, **Proceedings Words'03**, Turku (Finland), T. Harju and J. Karhumäki Editors, TUCS General Publication n. 27 (August 2003), 344-357.
- [C10] D. de Falco, M. Goldwurm, V. Lonati, *Frequency of symbol occurrences in simple non-primitive stochastic models*, **Proceedings DLT 2003**, 7<sup>th</sup> International Conference Developments in Language Theory, Szeged (Hungary) July 2003, Z. Esik and Z. Fülöp Editors, Lecture Notes in Computer Science n. 2710, Springer-Verlag (2003), 242-253 .
- [C9] M. Goldwurm, B. Palano, M. Santini, *On the circuit complexity of random generation problems for regular and context-free languages*, **Proceedings STACS 2001**, 18<sup>th</sup> Symposium on Theoretical Aspects of Computer Science, Dresden (Germany), February 2001, A. Ferreira and H. Reichel Editors, Lecture Notes in Computer Science n. 2010, Springer-Verlag (2001), 305-316 .
- [C8] A. Bertoni, M. Goldwurm, M. Santini, *Random generation and approximate counting of ambiguously described combinatorial structures*, **Proceedings STACS 2000**, 17<sup>th</sup> Symposium on Theoretical Aspects of Computer Science, Lille (France), February 2000, H. Reichel and S. Tison Editors, Lecture Notes in Computer Science n. 1770, Springer-Verlag (2000), 567-580.
- [C7] C. Choffrut, M. Goldwurm, *Rational transductions and complexity of counting problems*, **Proceedings 17th M.F.C.S.**, LNCS n.629, Springer-Verlag (1992), 181-190.
- [C6] A. Bertoni, D. Bruschi, M. Goldwurm, *Ranking and formal power series*, **Proceedings 1<sup>st</sup> Italian Conference in Algorithms and Complexity**, World Scientific (1991), 159-171.
- [C5] M. Goldwurm, *Some limit distributions in analysis of algorithms for problems on trace languages*, **Proceedings 3<sup>rd</sup> Italian Conference in Theoretical Computer Science**, A. Bertoni, C. Böhm, P. Miglioli editors, World Scientific (1989), 285-298.
- [C4] A. Bertoni, M. Goldwurm, *On the prefixes of a random trace and the Membership Problem for context-free trace languages*, **Proceedings 5<sup>th</sup> International Conference A.A.E.C.C.**, Applied Algebra, Algebraic Algorithms and Error-Correcting Codes, Menorca (Spagna), L. Huguët and A. Poli Editors, Lecture Notes in Computer Science n.356, Springer-Verlag (1989), 35-59.
- [C3] A. Bertoni, M. Goldwurm, N. Sabadini, *Analysis of a Class of Algorithms for Problems on Trace Languages*, **Proceedings 4<sup>th</sup> International Conference A.A.E.C.C.**, Applicable Algebra, Error-Correcting Codes, Combinatorics and Computer Algebra, Karlsruhe (RFT) Th. Beth and M. Clausen Editors, Lecture Notes in Computer Science n. 307, Springer-Verlag (1988), 202-214.
- [C2] A. Bertoni, M. Goldwurm, N. Sabadini, *Computing the Counting Function of Context-free Languages*, **Proceedings STACS 87**, 4<sup>th</sup> Symposium on Theoretical Aspects of Computer Science, Passau (RFT), F.J. Brandenburg, G. Vidal-Naquet, M. Wirsing Editors, LNCS n. 247, Springer-Verlag (1987), 167-179.
- [C1] A. Bertoni, M. Goldwurm, G. Mauri, N. Sabadini, *Parallel Algorithms and the Classification of Problems*, **Proceedings WOPLOT 86 - Parallel Processing : Logic, Organization, and Technology**, Monaco (RFT), J.D. Becker and I.Eisele Editors, LNCS n. 253, Springer-Verlag (1986), 206-226.

Periods of study abroad

He has carried out several periods of study and research in universities or research centres abroad. In particular he has been at the Coordinated Science Laboratory, University of Illinois at Urbana, USA (1987, prof. Franco Preparata), at the L.I.T.P. and L.I.A.F.A. of Université Paris VII (in 1994, 1997, 2000, 2003, 2004, 2005, prof. Christian Chuffrut), at the LaB.R.I. of Université Bordeaux I (2005, prof. Jean-Guy Penaud) and at the Dpt. of Mathematics of the University of Turku, Finland (2004, prof. Juhani Karhumäki).

TEACHING

He has taught the following topics at the "Università degli Studi di Milano" (8-9 hours per cfu):

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| <p>from 2015/16</p> <p>from 2015/16</p> <p>from 2016/17</p> <p>from 1995/96 to 2015/16</p> <p>from 2012/13 to 2014/15</p> <p>from 2006/07 to 2014/15</p> <p>2001/02 and 2002/03</p> <p>from 1993/94 to 1995/96</p> <p>1992/93</p> | <ul style="list-style-type: none"> <li>- <i>Algorithms</i>, degree in Mathematics, 5 cfu;</li> <li>- <i>Foundations of Computer Science</i>, master degree in Mathematics, 6 cfu;</li> <li>- <i>Probabilistic methods for Computer Science</i>, master degree in Computer Science, 6 cfu;</li> <li>- <i>Algorithms and data structures</i>, degree in Computer Science, 12 or 9 cfu;</li> <li>- <i>Algorithms and data structures II</i>, degree in Computer Science, 6 cfu;</li> <li>- <i>Stochastic processes (Markovian models)</i>, master degree in Computer Science, 6 cfu;</li> <li>- <i>Formal languages and automata</i>, degree in Computer Science, 6 cfu;</li> <li>- <i>Theory of formal languages</i>, degree in Mathematics, =12 cfu;</li> <li>- <i>Data bases</i>, degree in Computer Science, =12 cfu.</li> </ul> |
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Advisor He has been advisor, as "relatore" or "correlatore", of many undergraduate and master theses, both in Mathematics and Computer Science. He was also advisor of two doctorate dissertations in Computer Science (in 1999 and 2006) and "rapporteur" of Phd students' theses in other universities (Bordeaux in 2001, Stuttgart in 2004, Paris Marne-la-Vallée in 2007).

OTHER ACTIVITIES

Programme committees He was member of the programme committees of the following conferences:

- STACS 2003, Symposium on Theoretical Aspects of Computer Science, (Berlin, 27 February-1° March 2003);
- DLT 2007, Developments in Language Theory (Turku, 3-6 July 2007);
- DLT 2009, Developments in Language Theory (Stuttgart, 30/6-3/7 2009);
- SOFSEM 2010, 36<sup>th</sup> International Conference on Current Trends in Theory and Practice of Computer Science (track of Foundations of Computer Science), Spindlerun Mlyn, Rep. Ceca, 23 - 29 January 2010.

Research projects He has taken part in several local and national research projects as, for instance, MIUR-COFIN projects in 1999 and 2000, and MIUR-PRIN projects in 2003, 2005, 2007, 2010, concerning formal languages and automata theory.

Referee He has been referee of papers submitted to many conferences, including several issues of STACS, ICALP, CAAP, DLT, AFL, CIAA, DFCS, ICTC, MFCS, LATA, CPM. He has also been referee for several scientific journals, including Theoretical Computer Science, RAIRO Theoretical Informatics and Applications, Random Structures & Algorithms, Discrete Mathematics, Theory of Computing Systems. He also cooperated as editor to journal special issues (Theoretical Computer Science e RAIRO).

ADDITIONAL INFORMATION

Web site [users.mat.unimi.it/users/goldwurm/](http://users.mat.unimi.it/users/goldwurm/)

Mother tongue Italian

Other languages English, spoken French

Personal information I authorize the handling of personal information in this curriculum, according to D.Lgs n. 196/03 and following modifications and Regulations EU 679/2016 (General Regulations concerning Data Protection or GRDP) and art. 7 of University Regulations concerning protection of personal information.

Date 10<sup>th</sup> November 2018

Signature 