

Curriculum Vitae

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I am Full Professor of Algorithms and the Vice-Rector on ICT and Innovation at the University of Pisa.

I founded and lead the Acube Lab (*Advanced Algorithms and Applications*, <http://acubelab.di.unipi.it>) of the University of Pisa where we design algorithms and AI tools for Big Data, collaborating with major companies worldwide; such as Google, Bloomberg, Yahoo!, ST Microelectronics, ENEL, CERVED, Tiscali, etc.

I'm currently also a member of the Scientific Advisory Board of the Foundation on Innovation and Entrepreneurial Development (Pisa, Italy), a member of the Scientific Advisory Board of the collaboration between Foundation on Toscana Life Sciences (Siena, Italy) and University of Pisa, the representative member of the University of Pisa in the European Open Science Cloud (EOSC), one of the Board members of the PhD in Computer Science of the University of Pisa, and a member of the Advisory Board of the Master in Big Data, promoted by University of Pisa, CNR and the three excellence Italian schools (IMT Lucca, Scuola Superiore Sant'Anna e Scuola Normale Superiore).

I co-founded the startup *PlayeRank*, now spinoff of the University of Pisa (<http://playerank.it>), a Sports Analytics startup specialized in algorithms and AI techniques for the evaluation of performance of soccer players, the prediction of their injuries or for the planning of soccer matches based on Big Data.

Among the honors I got recently, I mention the Cherubino (2019), assigned by University of Pisa to distinguished Professors in Science and Professional activities, and the ACM Senior membership (2020).

Previous Institutional Roles. In 2019 I've been a Panel member of the EU Committee for the evaluation of *ERC Advanced Grants*.

From 2018 to 2020 I was the President of the Computer Science PhD joint program from the University of Pisa, Florence and Sienna.

From 2010 to 2016 I was Vice-Rector on "Applied Research and Innovation" at the University of Pisa. The two most significant initiatives during my term were: (1) the MIT-UniPI collaboration which led to the development of 30+ projects jointly pursued by researchers of MIT and UniPI over many scientific areas, not only ICT; (2) the *PhD Plus* program: a series of lectures on research valorization and entrepreneurial mindset for PhDs, Master students, and Faculties of the University of Pisa, starting from 2011. This program is still running, it got 800+ attendees and originated many start-ups that won (inter-)national competitions and raised funding worldwide. The PhD Plus program was shortlisted in the *QS Re-imagine Education Award 2016* (Philadelphia, PA) because of its strong impact in spreading the *innovation culture* among the Faculties of the University of Pisa, not just the ones interested in Entrepreneurship.

In the last years I was also the President of the IT Center of the University of Pisa (2009-2016), which has been recognized by Dell and Intel as a worldwide competence center on Cloud and HPC, and by Microsoft as Transform Data Center. Previously, I was vice-chairman of the Department of Computer Science of the University of Pisa (2006-2009), and the scientific coordinator of the *Signum* research center on Digital Humanities at the Scuola Normale Superiore in Pisa.

Education and Research interests. I got the PhD in Computer Science from the University of Pisa (1996), and the Post-doc from the Max-Planck Institut für Informatik (1998). Then I joined University of Pisa, where I am full professor since 2007. My professorship was initially sponsored by Yahoo! with a Faculty Award from 2006 to 2010 (the first in Europe at that time) because of my scientific achievements on the topic of Compressed and I/O-efficient data structures.

I have spent research periods in Academia and Industries: Harvard Medical School, and Massachusetts Institute of Technology (MIT), Max Planck Institut fuer Informatik (Saarbrücken, DE), Courant Institute (NYU, New York), University of North Texas, IBM Research (Rome), AT&T Shannon Lab (Florham Park, NJ), Yahoo! Research (Barcelona), Google (Zurich).

My research has been mainly devoted to the design, analysis and experimentation of algorithms and data structures for the compressed storage, mining and search of information in large amounts of data, mainly in the form of texts and (labeled) graphs. My results draw from the fields of String Matching, Information Theory, Data Compression, Graph Algorithms and, starting from 2006, also Web search and mining. I can describe my research by distinguishing four main periods/challenges:

- During the years of my PhD and post-doc, I investigated the design of I/O-efficient data structures for String Matching problems. The main result of my Phd Thesis was the String B-tree [ref. 1] mentioned nowadays in several US patents and, also, by Knuth as “elegant” at pag 489 of his *Vol. 3 of the Art of Computer Programming*. My thesis got the “EATCS Doctoral Dissertation Thesis Award” (1997) and the “Philip Morris Award on Science and Technology” (1997); moreover, it was ranked 4th in the “1997 ACM PhD Thesis” competition.
- In the year 2000, following a research period at AT&T Shannon Lab, I turned my attention to Information Theory. My main result has been the FM-index which is the first data structure supporting efficient substring searches over arbitrary data compressed up their k -th order entropy [ref. 3]. Researchers have recognized the FM-index as the first compressed version of the well-known suffix tree and suffix array data structures, as celebrated in the paper on the “40 years of Suffix Trees” (Comm. ACM, 2016). More importantly, the FM-index initiated the field of *compressed data structures*, nowadays the topic of thousands of publications (see e.g. the book by G. Navarro published by Cambridge University Press in 2016) and it plays a key algorithmic role in the two most famous genome-alignment tools, namely Bowtie and BWA, which are used by bio-researchers all over the world as witnessed by their 32k+ citations on Google Scholar. More recently, I was able to extend those ideas to labelled trees [ref. 4], graphs [ref. 9], etc..
- From 2005 I started working on Data Compression and got two main results. The first one is the *Compression Booster* [ref. 5], an inherently combinatorial technique that turns any *memoryless* compressor into a k th-order entropy compressor based on a suitable combination of the Burrows-Wheeler Transform and Suffix Trees. The second contribution [ref. 6] is the so called *bi-criteria compressor* that, given as input some data and a constant t , computes the Lempel-Ziv parsing of that data which is minimum in space and can be decompressed in time t (or, vice versa). Experimentally, the bi-criteria compressor dominates highly engineered competitors, such as Snappy, LZ4, bzip and LZMA. This research got a Google Faculty Award in 2016, and led very recently, among other things, to publish the first thorough and systematic description of the Brotli compressor, which is the open-source general-purpose data compressor introduced by Google in late 2013, and now adopted in most known browsers and Web servers [ref. 8].
- Since 2010 I have been interested in *Semantic Text Annotators* [ref. 9]. These algorithms are able to detect and annotate sequences of terms with unambiguous and pertinent entities drawn from a catalog (typically, Wikipedia). I lead the development of *TagMe*, which is currently the best known and most used open-source annotator in terms of efficiency and efficacy [ref. 13]. Some of the algorithmic ideas developed in the previous years have been used to make TagMe extremely efficient in time and space and successfully used in applications: such as news clustering [ACM WSDM '12] and classification [ECIR '12], analysis of hashtags in tweets [ICWSM '15], and entity salience and relatedness [NLDB '17, ACM CIKM '17]. TagMe has been released under Apache 2.0 License and its API interface has been queried more than 900mln times from academics and innovators. On this research I got two Google Faculty Awards (2010 and 2012), and a “Working Capital Award” from Telecom Italia (2010). Subsequently, TagMe has been used to design SMAPH a system for entity-annotation of Web queries that won the ERD 2014 Short Track Challenge at ACM SIGIR 2014 [ref. 14].¹

¹See the Google’s Research post: <https://plus.google.com/+ResearchatGoogle/posts/aqU7GrhXDLy>

Patents and Awards. I am co-inventor of 4 US Patents (owned by Lucent, University of Pisa and Rutgers, Yahoo!, and NYU), and two more patents are pending (owned by Catalog and University of Pisa). See <https://patents.google.com/?inventor=Paolo+Ferragina> .

My research got some international awards: “Best Land Transportation Paper Award” from IEEE Vehicular Technology Society (1995); “EATCS Doctoral Dissertation Thesis Award” (1997); “Philip Morris Award on Science and Technology” (1997); “Research Capital award” from the University of Pisa (2002); Yahoo! faculty award (2006-2010); Working Capital Award from Telecom Italia (2010); three Google research awards (2010, 2012 and 2016); and a Bloomberg Data Science research grant (2017).

In the year 2012, I was selected by Google EMEA as one of the “top-100 renowned scientists” due to my research on Search Engines and Information Retrieval.

Conferences keynotes and co-chairs. I have been plenary speaker at the conferences CPM ’04, SPIRE ’05, ESA/ALGO 2010, SISAP 2011, ECIR Industrial-Track 2012, DFG Priority Program 1307 “Algorithm Engineering” (Germany), DIITET 2015 National Conference of CNR (Pisa), Satellite Workshop on Quantifying Success NETSCI (Parigi, 2018), INNS Conference on Big Data and Deep Learning (Venezia, 2019), Italian Conference on Theoretical Computer Science (Ischia, ICTCS 2020).

I have been a member of the steering committees of the conferences: Symposium on String Processing and Information Retrieval (SPIRE, from 2006 to 2009), European Symposium on Algorithms (ESA, from 2012 to 2014), and of the Lipari PhD School su “Computational Complex and Social Systems” (since 2016).

I’ve been co-chair of the International Conference on FUN with Algorithms (2004), DIMACS Workshop on the Burrows-Wheeler Transform (2004), Symposium on String Processing and Information Retrieval (SPIRE 2006), Symposium on Combinatorial Pattern Matching (CPM 2008), European Symposium on Algorithms (ESA 2012), ACM Conference on Web Search and Data Mining (WSDM 2013). In 2019 I have been the co-chair of the Indo-Italian School on “Algorithms and Combinatorics” that took place within the 5th Annual International Conference on Algorithms and Discrete Applied Mathematics (IIT Kharagpur, India).

I have served as PC member of many Theoretical Computer Science conferences, specifically in the field of Algorithmics (i.e. ESA, ICALP, CPM, etc.) and IR (i.e. WWW, WSDM, SPIRE, etc.).

Journals and Books. Since 2011 I’m in the Editorial Board of the Journal on Graph Algorithms and Applications (JGAA), and I have served as (co)editor of 5 special issues in Theory of Computing Systems (2006), Theoretical Computer Science (2007 and 2009), Information Retrieval (2008), Algorithmica (2014). I was one of the Area Editors of the Encyclopedia of Algorithms (Springer, Editor Ming-Yang Kao, 2016), and of the Encyclopedia of Big Data Technologies (Springer, Editor Zomaya and Sakr, 2018).

I (co-)authored more than 170 (refereed) publications in journals — such as 5 JACM, 2 SICOMP, 4 ACM Trans on Algorithms, 2 ACM Trans. on Information Systems, 7 Algorithmica, 6 TCS, 2 ACM J. on Exp. Algorithmics, 2 Information and Computation, etc.. — and conferences — such as 3 ACM STOC, 5 IEEE FOCS, 7 ACM-SIAM SODA, 13 ESA, 6 WWW, 3 ACM WSDM, etc..

I have also co-authored two Italian books: one on Cryptography (Bollati Boringhieri, 2001 and 2007; now UniPI Press, 2015), and one on Computational Thinking (Il Mulino, 2017) which has been recently translated in English and published by Springer (2018).

I have also contributed to several Encyclopedia’s entries by Springer (on Algorithms, on DataBases, and on BigData Technologies) and various book chapters: e.g. “String search in external memory: Algorithms and data structures” in the “Handbook of Computational Molecular Biology” (CRC Press, 2005), “Web Search” in the book “On the power of algorithms” (Springer, 2013), and “Computational Biology” in the “Handbook of Data Structures and Applications” (Chapman and Hall/CRC, 2018).

My H-index on Google Scholar is 38 with about 9500 citations, at September 2021 (this is 32 on Scopus with 5200 cit.). For more details have a look at: <http://pages.di.unipi.it/ferragina>, DBLP and Google Scholar.

Teaching and Advising students. I am/was teaching since several years a course on Basic Algorithms for the Bachelor in Computer Science at University of Pisa, and several advanced courses on BioInformatics,

Data Compression, Algorithm Engineering and Information Retrieval for the Master Degree in Computer Science and some International PhD Schools.

I'm also one of the Scientific Board Members of the Master in Big Data, promoted by University of Pisa, CNR and the three excellence Italian schools (IMT Lucca, Scuola Superiore Sant'Anna e Scuola Normale Superiore).

I have advised more than 80 bachelor and master thesis and 14 PhD Thesis, of which 5 are currently under development. My PhD students found positions in Academia and top companies such as Google (4) and Bloomberg (1).

10 most significant publications

1. P. Ferragina, R. Grossi. The String B-tree: a new data structure for string search in external memory and its applications, *Journal of the ACM*, 46(2), 1999. Its conference version appeared in the *Procs ACM STOC 2005*.
2. M. Farach, P. Ferragina, S. Muthukrishnan. On the sorting complexity of suffix tree construction. *Journal of the ACM*, 47(6), 2000. Its conference version appeared in the *Procs IEEE FOCS 1998*.
3. P. Ferragina, G. Manzini. Indexing compressed texts. *Journal of the ACM*, 52(4), 2005. Its conference version appeared in the *Procs IEEE FOCS 2000*.
4. P. Ferragina, F. Luccio, G. Manzini, S. Muthukrishnan. Compressing and indexing labeled trees, with applications. *Journal of the ACM*, 57(1), 2009. Its conference version appeared in the *Procs IEEE FOCS 2005* and *Procs WWW 2006*.
This result is the subject of the US Patent no. US8156156 (10 apr '12).
5. P. Ferragina, F. Piccinno, R. Venturini. Compressed indexes for string-searching in labeled graphs. In *Procs WWW*, 2015.
6. P. Ferragina, R. Giancarlo, G. Manzini, M. Sciortino. Compression boosting in optimal linear time. *Journal of the ACM*, 52(4), 2005. Its conference version appeared in the *Procs ACM-SIAM SODA 2004*.
7. A. Farruggia, P. Ferragina, A. Frangioni, R. Venturini. Bicriteria data compression. *SIAM Journal on Computing*, 2019. Its conference version appeared in the *Procs ACM-SIAM SODA*, 2014 (theory part), and in the *Procs of the European Symposim on Algorithms (ESA)*, 2014 (experimental part).
8. J. Alakuijala, A. Farruggia, P. Ferragina, *et alii*. Brotli: A general-purpose data compressor. *ACM Transactions on Information Systems*, 2019.
9. P. Ferragina, U. Scaiella. Fast and accurate annotation of short texts with Wikipedia pages. *IEEE Software*, 29(1), 2012. Its conference version appeared in the *Procs ACM CIKM 2010*.
10. M. Cornolti, P. Ferragina, M. Ciaramita, S. Rued, H. Schutze. A piggyback system for joint entity mention detection and linking in Web queries. *ACM Transactions on Information Systems*, 2019. Its conference version appeared in the *Procs WWW*, 2016. (Winner of the Short-Track competition at the Workshop ERD, hosted by ACM SIGIR 2014.)

Pisa, 5 November 2021



Full list of publications

Journals

- [1] N. Burgess, S. Di Zenzo, P. Ferragina, M. Notturmo Granieri. The generalization of a constructive algorithm in pattern classification problems. *International Journal of Neural Systems: Supplementary Issue on the Second Workshop on Neural Networks– from Biology to High Energy Physics*, World Scientific Publishing, vol. 3, 65-70, 1992.
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- [3] C. Calabrò, P. Ferragina, M. Notturmo Granieri. Recognition of hand-written rotated digits by neural networks. *Machine Vision and Applications*, Springer Verlag, vol. 8, 351–358, 1995.
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- [5] P. Ferragina. Static and dynamic parallel computation of connected components. *Information Processing Letters*, vol. 50(2), 63–68, 1994.
- [6] P. Ferragina. A technique to speed up parallel fully dynamic algorithms for MST. *Journal of Parallel and Distributed Computing*, vol. 31(2), 181–189, 1995.
- [7] P. Ferragina, F. Luccio. Three techniques for parallel maintenance of a minimum spanning tree under batch of updates. *Parallel Processing Letters*, vol. 6(2), 213–222, 1996.
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- [9] P. Ferragina, R. Grossi. Optimal on-line search and sublinear time update in string matching. *SIAM Journal on Computing*, vol. 27(3), 713–736, 1998.
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- [13] P. Ferragina, F. Luccio. String search in coarse-grained parallel computers. *Algorithmica: Special issue on Coarse-Grained Parallel Computers*, Editor Frank Dehne, vol. 24(3), 177–194, 1999.
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- [15] P. Ferragina, R. Grossi. The String B-Tree: A New Data Structure for String Search in External Memory and its Applications. *Journal of the ACM*, vol. 46(2), pp. 236–280, March 1999.
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(Chapters of) Books and Special Issues

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