LE GALL, François Professor

Office: Rm 404 in Math. Bldg.
Phone: +81 (0) 52−789−2412 (ext. 2412)
Email: legall@math.nagoya-u.ac.jp
Web-site: http://www.francoislegall.com/

Membership of Academic Societies:
Information Processing Society of Japan, The Mathematical Society of Japan, Association for Computing Machinery

Research Interest:

- Algorithms
- Computational complexity
- Quantum computing

Research Summary:

My research area is theoretical computer science, the field of study that investigates computation from a mathematical perspective. I am especially working on algorithms, computational complexity and quantum computing.

My research on algorithms focuses on graph algorithms and algebraic algorithms. For algebraic algorithms, in particular, my main objective is to develop good algorithms for algebraic problems that appear in several areas of science and technology. Concretely, I have discovered algorithms for isomorphism testing of algebraic structures such as groups, and for fundamental operations in linear and bilinear algebra. For instance, one of my results (Ref. [6]) focuses on the complexity of matrix multiplication, which is one of the main open problems in theoretical computer science, and makes progress on this question.

Complexity theory is another central problem in theoretical computer science. Its goal is to clarify the computational power of several computation models and prove their limitation (i.e., prove what they cannot compute). The most famous open problem in this field is the P≠NP conjecture, which was selected as a Millenium Problem by the Clay Institute. Recently, I am especially interested in the computational complexity of distributed computing.

Quantum computing is a paradigm for computation based on the laws of quantum mechanics. My most representative result is improving the quantum complexity of the triangle finding problem (Ref. [7]). This problem, studied in the quantum setting for more than 15 years, asks to decide whether a given n-node graph contains a triangle or not. While prior works found a quantum algorithm with running time $O(n^{9/7})$, my result further reduced the complexity to $O(n^{5/4})$.

Major Publications:

[1] S. Gharibian and F. Le Gall. Dequantizing the Quantum Singular Value Transformation: Hardness and Applications to Quantum Chemistry and the Quantum PCP Conjecture. *Proceedings of the 54th ACM Symposium on Theory of Computing*, 19–32, 2022.

[2] F. Le Gall. Average-Case Quantum Advantage with Shallow Circuits. *Proceedings of the 34th Computational Complexity Conference*, 21:1–21:20, 2019.

[3] T. Izumi and F. Le Gall. Triangle Finding and Listing in CONGEST Networks. *Proceedings of the 36th ACM Symposium on Principles of Distributed Computing*, pp. 381–389, 2017.

[4] D. Doron, F. Le Gall and A. Ta-Shma. Probabilistic Logarithmic-Space Algorithms for Laplacian Solvers. *Proceedings of the 21st International Workshop on Randomization and Computation*, pp. 41:1–41:20, 2017.

[5] H. Kobayashi, F. Le Gall and H. Nishimura. Stronger Methods of Making Quantum Interactive Proofs Perfectly Complete. *SIAM Journal on Computing*, Vol. 44(2), pp. 243–289, 2015.

[6] F. Le Gall: Powers of Tensors and Fast Matrix Multiplication. *Proceedings of the 39th International Symposium on Symbolic and Algebraic Computation*, pp. 296–303, 2014.

[7] F. Le Gall: Improved Quantum Algorithm for Triangle Finding via Combinatorial Arguments. *Proceedings of the 55th Annual IEEE Symposium on Foundations of Computer Science*, pp. 216–225, 2014.

Awards and Prizes:

- NISTEP Award (2017)
- ISSAC 2014 Distinguished Paper Award (2014)

Education and Appointments:

2006	PhD, Graduate School of Information Science and Technology, The University of Tokyo
2006	Researcher, ERATO-SORST Quantum Computation and Information Project, Japan Science and Technology Agency
2009	Project Lecturer, Graduate School of Information Science and Technology, The University of Tokyo
2012	Project Associate Professor, Graduate School of Information Science and Technology, The University of Tokyo
2016	Program-Specific Associate Professor, Graduate School of Informatics, Kyoto University
2019	Associate Professor, Graduate School of Mathematics, Nagoya University
2022	Professor, Graduate School of Mathematics, Nagoya University

Message to Prospective Students:

- My seminar for graduate research mainly focuses on quantum computation and quantum information, but other topics in theoretical computer science (for instance, algorithms or complexity theory) are also possible. Students can basically choose any topic related to those subjects.
- The first months of research are devoted to studying textbooks. The choice of the textbook depends on the subject and the students' background. The following are often selected.
  - [1] Masahito Hayashi, Satoshi Ishizaka, Akinori Kawachi, Gen Kimura and Tomohiro Ogawa. *Introduction to Quantum Information Science*. Springer, 2015.
  - [2] M. Nielsen and I. Chuang. *Quantum Computation and Quantum Information.* Cambridge University Press, 2010.
- Students then start reading technical research papers and getting familiar with recent research. After choosing an appropriate open problem (by discussing with me), they are expected to conduct original research.