

Frank (Peng) Fu

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Education

- Ph.D. Department of Computer Science, University of Iowa, Iowa City, Iowa, USA. September 2009 – August 2014. Advisor: Aaron Stump. Thesis Title: Lambda encodings in type theory.
- B.Eng. School of Computer Science, Huazhong University of Science and Technology, Wuhan, Hubei, China. September 2005 – June 2009.

Research interests

- Quantum programming languages.
- Interactive theorem proving and language-based formal verification.
- Type theory, dependent types, lambda calculus and their applications.

Refereed conference publications

C1 **Linear dependent type theory for quantum programming languages.**

Peng Fu, Kohei Kishida, Peter Selinger, 35th Annual ACM/IEEE Symposium on Logic in Computer Science, LICS 2020.

C2 **A tutorial introduction to quantum circuit programming in dependently typed Proto-Quipper.**

Peng Fu, Kohei Kishida, Neil J. Ross, Peter Selinger, 12th Conference on Reversible Computation, RC 2020.

C3 **Proof relevant corecursive resolution.**

Peng Fu, Ekaterina Komendantskaya, Tom Schrijvers, Andrew Pond. 13th International Symposium on Functional and Logic Programming, FLOPS 2016.

C4 **A type-theoretic approach to resolution.**

Peng Fu, Ekaterina Komendantskaya. 25th International Symposium on Logic-Based Program Synthesis and Transformation, LOPSTR 2015.

C5 **Self types for dependently typed lambda encodings.**

Peng Fu, Aaron Stump. Joint 25th International Conference on Rewriting Techniques and Applications and 12th International Conference on Typed Lambda Calculi and Applications, RTA-TLCA 2014.

Refereed journal publications

J1 **Linear dependent type theory for quantum programming languages.**

Peng Fu, Kohei Kishida, Peter Selinger, accepted in the special issue of Logical Methods in Computer Science (LMCS) devoted to selected papers from LICS 2020

J2 **Operational semantics of resolution and productivity in horn clause logic.**

Peng Fu, Ekaterina Komendantskaya. Formal Aspect of Computing, 2017. Journal Version of C4.

J3 **Efficiency of lambda-encodings in total type theory.**

Aaron Stump, **Peng Fu**. Journal of Functional Programming, 2016.

Refereed workshop publications

W1 **Equational reasoning about programs with general recursion and call-by-value semantics.**

Garrin Kimmell, Aaron Stump, Harley Eades III, **Peng Fu**, Tim Sheard, Stephanie Weirich, Chris Casinghino, Vilhelm Sjöberg, Nathan Collins, Ki Yung Ahn. Programming Languages meets Program Verification, PLPV 2012.

W2 **Irrelevance, heterogeneous equality, and call-by-value dependent type Systems.**

Vilhelm Sjöberg, Chris Casinghino, Ki Yung Ahn, Nathan Collins, Harley Eades III, **Peng Fu**, Garrin Kimmell, Tim Sheard, Aaron Stump, Stephanie Weirich. Mathematically Structured Functional Programming, MSFP 2012.

W3 **A framework for internalizing relations into type theory.**

Peng Fu, Aaron Stump, Jeff Vaughan. International Workshop on Proof-Search in Axiomatic Theories and Type Theories, PSATTT 2011.

Manuscripts

M1 **Dependently typed folds for nested data types.**

Peng Fu, Peter Selinger, 2018, available at arXiv: <https://arxiv.org/abs/1806.05230>.

M2 **A type checking algorithm for higher-rank, impredicative and second-order Types.**

Peng Fu, 2017, available at arXiv: <http://arxiv.org/abs/1711.04718>.

M3 **Representing nonterminating rewriting with F_2^μ .**

Peng Fu, 2017, available at arXiv: <http://arxiv.org/abs/1706.00746>.

Professional experience

- Postdoctoral Researcher, Dalhousie University, Halifax, Nova Scotia, Canada. May 2017 – present.
 - Supervisor: Peter Selinger.
 - Developing type systems and languages for programming quantum circuits.
 - * Publications: J1, C1, C2.
 - * Prototype implementation: S1.
 - Developed a technique to allow programming and reasoning about nested data types in the dependently typed language Agda.
 - * Manuscript: M1.

* Agda programs: S2.

- Lecturer (co-instructor), Discrete Structures I (online), Dalhousie University, Canada. May 1, 2020 – July 31, 2020.
- Lecturer, Discrete Structures I, Dalhousie University, Canada. May 1, 2019 – July 31, 2019.
- Postdoctoral Researcher, University of Dundee and Heriot-Watt University, Scotland, UK. October 2014 – August 2016.
 - Applied techniques from logic programming and theorem proving to solve a type class problem.
 - Publications: C3, C4, J2.
 - Prototype implementation: S3.

Prototypes and programs

S1 **Dependently typed Proto-Quipper** (Source: <https://gitlab.com/frank-peng-fu/dpq-remake>). A language for programming quantum circuits. Main features:

- Linear and dependent types for programming quantum circuits.
- A bidirectional type checker that supports linear types, polymorphic types and dependent types.

S2 **Dependently typed folds for nested data types** (Source: <https://github.com/fermat/dependent-fold>). Currently it is hard to program and reason about nested data types in total dependently typed languages. We give a collection of examples in the dependently typed language Agda to show how to program and reason about nested data types using dependently typed folds.

S3 **Corecursive type class** (Source: <https://github.com/fermat/corecursive-type-class>). An interpreter and type checker that implements a type class mechanism based on corecursive resolution. Main features:

- It supports dictionary construction for nonterminating type class resolution.
- It uses a goal directed automated proof construction to construct type class evidence.
- It provides a heuristic algorithm for generating intermediate lemmas during the proof construction.

Conference and workshop presentations

- **Proto-Quipper: a quantum programming language**, July 2nd, 2021, Logic, Quantum Computing, and Artificial Intelligence, Online workshop.
- **Linear dependent theory for quantum programming languages**, June 11th, 2021, QPL, Online conference.
- **Linear dependent theory for quantum programming languages**, July 8th, 2020, LICS, Online conference.
- **A tutorial introduction to quantum circuit programming in dependently typed Proto-Quipper**, July 10th, 2020, RC, Online conference.
- **Dependent types in Proto-Quipper**, September 20, 2018, Dagstuhl Seminar: Quantum Programming Languages, Dagstuhl, Germany.
- **Proof relevant corecursive resolution**. June 22, 2016, The Scottish Programming Languages Seminar, Heriot-Watt University, Edinburgh, UK.

- **A type-theoretic approach to structural resolution.** July 13, 2015, LOPSTR, Siena, Italy.
- **Self types for dependently typed lambda encodings.** July 15, 2014, RTA-TLCA, Vienna, Austria.
- **Dependent lambda encoding with self types.** September 2013, ACM SIGPLAN Workshop on Dependently-Typed Programming(DTP), Boston, MA.
- **A framework for internalizing relations into type theory.** August 2011, PSATTT workshop, Wroclaw. Poland.

Teaching experience

- Teaching assistant, “Topic in Logics: theorem proving in Agda”, 2021 Spring, Dalhousie University.
 - Prepared homework and projects.
 - Held online office hours and answered questions using an online forum.
 - Graded homework and projects.
 - Prepared extra videos to explain homework problems.
- Lecturer (Co-instructor), “Discrete structures I”, 2020 Summer, Dalhousie University.
 - Taught basic set theory, relations, induction and basic number theory.
 - Delivered a total of 17 online lectures (class size: around 190).
 - Held office hours online and answered questions using an online forum.
 - Developed class material, quizzes, assignments and exams.
- Lecturer, “Discrete structures I”, 2019 Summer, Dalhousie University.
 - Taught basic set theory, relations, formal logic, proofs, basic counting and basic number theory.
 - Delivered three lectures per week (total 35 lectures, class size: around 30).
 - Held office hours twice a week.
 - Developed class material, assignments and exams.
- Teaching Assistant, “Introduction to functional programming in Haskell”, 2015 Spring. Computer Science, University of Dundee.
 - Taught basic functional programming in Haskell, the first Haskell class taught in University of Dundee.
 - Delivered one lecture per week (total 13 lectures, class size: around 50).
 - Ran one lab session per week.
 - Developed class material, assignments and part of the final exam.
- Graduate Teaching Assistant, “Programming Language Concepts”, 2013 Spring, 2014 Spring. Department of Computer Science, The University of Iowa.
 - Developed grading scripts.
 - Graded assignments (Class size: around 70 both times).
 - Ran weekly office hours.
 - Observed lectures.

- Graduate Teaching Assistant, “Object-Oriented Software Development ”, 2013 Fall. Department of Computer Science, The University of Iowa.
 - Graded assignments (Class size: around 70).
 - Ran one lab session per week.
 - Ran weekly office hours.
 - Observed lectures.
- Graduate Teaching Assistant, “Computer Networking”, 2009 Fall. Department of Computer Science, The University of Iowa.
 - Graded assignments (Class size: around 30).
 - Ran weekly office hours.
 - Observed lectures.

Professional service

- External Reviewer. Logical Methods in Computer Science (2021). Reviewed: 1 paper.
- External Reviewer. Quantum journal (2020). Reviewed: 1 paper.
- External Reviewer. 24th International Conference on Rewriting Techniques and Applications (RTA 2013). Reviewed: 1 paper.
- External Reviewer. 19th International Conference on Foundations of Software Science and Computation Structures (FoSSaCS 2016). Reviewed: 1 paper.
- External Reviewer. 32nd International Conference on Logic Programming (ICLP 2016). Reviewed: 1 paper.