Norihiro Yamada

Curriculum Vitae

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Citizenship: Japan

Research interests (mathematics and computer science)

Mathematical logic	game semantics; (higher-order) recursion theory; foundations of mathematics and constructive mathematics; homotopy type theory
Category theory	categorical algebra; categorical logic
Topology	constructive topology; connections between logic and topology
Theoretical computer science	applications of mathematical logic, category theory and topology to theoretical computer science

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Appointments

2019–present	**Postdoctoral Research Scholar**, *The University of Minnesota*. Research on game semantics and type theory, advised by Favonia.
2019 (Feb–Mar)	**Postdoctoral Research Fellow**, *Kyoto University*. Research on categorical logic, advised by Yoshihiro Maruyama.
2012 (Apr–Jul)	**Research Assistant**, *Japan Science and Technology Agency*. Research on computational group theory, advised by Shin-ichi Minato.
2011 (Apr–Jun)	**Teaching Assistant**, *Hokkaido University*. Teaching assistant for a lecture course on theory of computation.
2011 (Apr–May)	**Lecturer**, *Japan Science and Technology Agency*. Lectures on abstract algebra.

Education

2012–2018	**DPhil in Computer Science (specif. Logic, Foundations and Structures)**, *The University of Oxford*. Thesis on game semantics, higher-order recursion theory and constructive mathematics, advised by Samson Abramsky and Bob Coecke. Ranked first on the first year exams on logic and mathematics in the year 2012–2013.
2009–2010	**Exchange Program in Mathematics**, *The University of Wisconsin-Madison*. Final year undergraduate courses on pure mathematics, advised by Ken Ono. GPA: 4.00/4.00.
2007–2012	**BEng in Computer Science**, *Hokkaido University*. Thesis on computational group theory, advised by Shin-ichi Minato. Whilliam Wheeler Prize (the best student award).

Doctoral thesis

Title *Games as Mathematics of Logic and Computation*

Supervisors Samson Abramsky and Bob Coecke

Description The thesis establishes a mathematical, in particular semantic and analytic, foundation of higher-order logic and computation, and constructive mathematics, including their dynamics and intensionality, in terms of game semantics.

Publications

2020 **Dynamic game semantics**, *joint work with Samson Abramsky*, *Mathematical Structures in Computer Science*, doi: 10.1017/S0960129520000250.

This work refines game semantics in such a way that it models *dynamics* (or *normalisation*) and *intensionality* (or *algorithms*) of proofs and programs. Further, this *dynamic game semantics* is abstracted categorically, which refines the standard categorical semantics in cartesian closed categories into the one in *cartesian closed bicategories*. In this way, this work achieves the mathematical elegance of *denotational semantics* and the dynamics/intensionality of *operational semantics* in a single framework. *Mathematical Structures in Computer Science* is a leading journal on mathematical, especially algebraic and logical, methods in the context of theoretical computer science.

2018 **A game-semantic model of computation**, *Research in the Mathematical Sciences, **6**(1), 3 (2019)*.

This work expands dynamic game semantics into a mathematical model of computation that generalises the standard *Church–Turing computability* on natural numbers in an intrinsic (i.e., without having recourse to any existing computability), semantic, analytic fashion. It formulates *computability* in a highly primitive, convincing fashion just like Turing machines yet beyond computability on natural numbers, e.g., *higher-order* computability. Also, it generalises, as immediate corollaries, well-known theorems in recursion theory such as the *smn-theorem* and the *first recursion theorem*, and the restriction of the generalised computability to natural numbers coincides with the Church–Turing computability. *Research in the Mathematical Sciences* is a relatively new yet very strong mathematics journal whose acceptance rate is less than 10%, and even Fields medalists publish breakthrough articles in this journal.

Preprints

2021 **Game-semantic ∞-groupoids and semantics of homotopy type theory**, In preparation (coming very soon).

This work establishes *game semantics of homotopy type theory (HoTT)*. It models formal proofs in HoTT by *effective computations*, achieving a directly computational, specifically *Brouwer-Heyting-Kolmogorov (BHK)*, interpretation of HoTT. In particular, it gives an answer to a central problem in HoTT in the affirmative: There is a BHK-interpretation of Voevodsky's *univalence axiom*, the heart of HoTT, which directly justifies the *constructivity* of the axiom. Also, as a corollary of this game semantics, we solve another open problem: the *consistency* of HoTT with the *equational* univalence axiom, i.e., Id-type on a universe is *judgementally equal* to type equivalence.

2021 **Categorical algebra for a unity of logic**, In preparation.

This work establishes the categorical and the game-semantic counterparts of the unity of logic given by sequent calculi (see below), for which a certain class of idempotent, strong monads and comonads play crucial roles.

2020 **Game semantics of Martin-Löf type theory, part III: its consistency with formal Church's thesis**, *arXiv preprint arXiv:2007.08094*.

This work proves the *consistency of intensional Martin-Löf type theory (MLTT) with formal Church's thesis (CT)*, which was open for at least fifteen years. The difficulty in proving the consistency is that a standard method of *realisability à la Kleene* does not work for the consistency, though it validates CT, as it does not model MLTT; specifically, the realisability does not validate MLTT's congruence rule on Pi-type (known as the ξ-rule). The present work overcomes this point and proves the consistency by novel *game semantics*, which is based on the previous work (part I).

2020 **Sequent calculi for a unity of logic**, *arXiv preprint arXiv:2001.06138*.

We present a novel *unity of logic*, viz., a single sequent calculus that embodies classical, intuitionistic and linear logics. Concretely, we define *classical linear logic negative* (CLL^-), a new logic that is *classical* and *linear* yet discards the *polarities* and the *(strict) de Morgan laws* in classical linear logic (CLL). Then, we define *unlinearisation* and *classicalisation* on sequent calculi such that unlinearisation maps CLL^- (resp. intuitionistic linear logic (ILL)) to classical logic (CL) (resp. intuitionistic logic (IL)), and classicalisation maps IL (resp. ILL) to CL (resp. CLL^-) modulo conservative extensions. By these two maps, only a sequent calculus for a conservative extension of ILL suffices for ILL, IL, CLL^- and CL. This result achieves a *simple*, highly *systematic* unity of logic by discarding the polarities and the de Morgan laws, which (arguably) *only CLL has*, and consisting of the *uniform* classicalisation and unlinearisation, which *commute*. Previous methods do not satisfy these points. Our unity of logic also clarifies the dichotomies between *intuitionisity* and *classicality*, and between *linearity* and *non-linearity* of logic, which are completely *symmetric*.

2019 **Game semantics of Martin-Löf type theory, part I**, *arXiv preprint arXiv:1610.01669*.

We present new *game semantics* of *Martin-Löf type theory (MLTT)* equipped with One-, Zero-, N-, Pi-, Sigma- and Id-types as well as universes. It interprets both Id-type and universes in the presence of N-type for the first time as game semantics. Its another advantage is its interpretation of Sigma-type that is *direct* and *compatible with the game semantics of linear logic*. Also, its mathematical structure is quite novel and useful; e.g., the category of our games has all *finite limits*, which is a key step for an extension of the present work to *homotopy type theory*. Finally, we provide a new, game-semantic proof of the *independence of Markov's principle* from MLTT, which demonstrates an advantage of our game semantics over extensional models of MLTT such as realisability models.

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Mar, 2012 **Whilliam Wheeler Prize**, *Hokkaido University*.
The best student award in each academic discipline of the school of engineering.

Nov, 2011 **Funai Overseas Scholarship**, *Funai Foundation for Information Technology*.
A highly competitive scholarship for Japanese students in natural sciences, mathematics, computer science, engineering and economics to study in PhD programs at world-leading universities in foreign countries. 11 recipients in 2011.

Jun, 2008 **Inoue Scholarship**, *Inoue Scholarship Foundation*.
15 recipients from top 9 Japanese universities in any academic disciplines in 2008.

Jun, 2008 **Nitobe Prize**, *Hokkaido University*.
Awarded top 90 students out of 2,700 freshmen in all academic disciplines in 2008.

Invited talks

May, 2021	**Finite limits in games**, *The University of Amsterdam*. Categories and Types Seminar (online), invited by Benno van den Berg.
Feb, 2021	**Game semantics of homotopy type theory**, *Western University*. Homotopy type theory electronic seminar talks (online), invited by Chris Kapulkin.
Sep, 2020	**Game semantics for the consistency of Church's thesis with Martin-Löf type theory**, *The University of Padova*. The mathematical logic seminar (online), invited by Maria Maietti.
Apr, 2018	**A game-semantic model of computation**, *Hokkaido University*. The theoretical computer science seminar, invited by Thomas Zeugmann.
Nov, 2017	**Game semantics of Martin-Löf type theory**, *Stockholm University*. The mathematical logic seminar, invited by Erik Palmgren.
Nov, 2017	**Game semantics of Martin-Löf type theory**, *The University of Leeds*. The mathematical logic seminar, invited by Nicola Gambino.
Oct, 2017	**Game semantics of Martin-Löf type theory**, *The University of Nottingham*. The functional programming seminar, invited by Thorsten Altenkirch.
Aug, 2017	**Game semantics of Martin-Löf type theory**, *Stockholm University*. The international conference *CSL 2017*, peer-reviewed.
Aug, 2015	**Dynamic games and strategies**, *University College Cork*. The international conference *Domains XII*, peer-reviewed.
May, 2015	**Dynamic games and strategies**, *The University of Birmingham*. The theory of computation seminar, invited by Dan Ghica.

Teaching experience

2011 (Apr–Jun)	**Teaching Assistant**, *Hokkaido University*. Teaching assistant for a lecture course on theory of computation.
2011 (Apr-May)	**Lecturer**, *Japan Science and Technology Agency*. A short course on abstract algebra in the final year undergraduate level.

Languages

Native language	Japanese
Second language	English (fluent)