MINGSHUAI CHEN

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EMPLOYMENT

Dept. of Computer Science, RWTH Aachen University   Sep. 2019 - present
Postdoctoral researcher at Software Modeling and Verification Group   *Head: Prof. Dr. Joost-Pieter Katoen*

EDUCATION

Institute of Software, Chinese Academy of Sciences   Sep. 2013 - Jun. 2019
Ph.D. in Computer Science (with honour) at St. Key Lab. of Comput. Sci.   *Advisor: Prof. Dr. Naijun Zhan*

· Dissertation: Verification and Synthesis of Time-Delayed Dynamical Systems
· Award: CAS-President Special Award

Dept. of Computing Science, Carl von Ossietzky Universität Oldenburg   Fall, 2015 - 2018
Visiting scholar at Hybrid Systems Group   *Advisor: Prof. Dr. Martin Fränzle*

College of Computer Science and Technology, Jilin University   Sep. 2009 - Jun. 2013
B.Sc. in Computer Science (with honour)

RESEARCH INTERESTS

My primary research interest lies in the general scope of *formal verification* and *synthesis*, broadly construed in *mathematical logic* and *theoretical computer science. I develop formal reasoning techniques for programs and hybrid discrete-continuous systems for ensuring the reliability and effectiveness of safety-critical cyber-physical systems, and aim to push the limits of automation as far as possible.* This is an interdisciplinary subject that spans the realms of mathematics, computer science, and control theory. Topic-wise, I am interested in semantics and qualitative/quantitative verification of computer programs; modelling, verification, and synthesis of hybrid systems; reachability analysis; invariant/interpolant/controller synthesis; time-delayed systems; and cyber-physical systems. The formal techniques that I am interested in include computer algebra, symbolic computation, quantitative inference, automated/interactive theorem proving, (non-)convex optimization, SAT/SMT-solving, abstract interpretation, differential dynamics, algorithmic game theory, process algebra, interval arithmetic, temporal logic, etc. Recently, I took an interest in the principles of probabilistic programming, with the main focus on automatic verification and semi-automated generation of loop invariants for infinite-state probabilistic programs and techniques for determining termination properties.

ACADEMIC SERVICES

Teaching Assistant

Trends in Computer-Aided Verification, B.Sc./M.Sc., Seminar in Theoretical CS, RWTH Aachen	SS 21/22
Concurrency Theory, M.Sc., RWTH Aachen	WS 21-22
Probabilistic Programming, B.Sc./M.Sc., Seminar in Theoretical CS, RWTH Aachen	WS 20-21
Theoretical Foundations of the UML, M.Sc., RWTH Aachen	SS 20
Theories of Programming, M.Sc., UCAS	WS 17-18/18-19

Committee Member

Reviewer Panel of Mathematical Reviews	Oct. 2021 - present
Program Committee Member of SYNASC 2022 (Logic and Programming Track)	Sep. 2022
Program Committee Member of RTCSA 2021	Aug. 2021
Repeatability Evaluation Program Committee Member of ADHS 2021	Jul. 2021
Artifact Evaluation Committee Member of VMCAI 2021	Jan. 2021

External Reviewer

POPL '23, ICALP '22, TASE '22/15, SAFECOMP '22, CAV '21/20, ADHS '21/18, ECC '21/16, TACAS '21, HSCC '20, FORMATS '20, RTSS '19, EMSOFT '19, MEMOCODE '18, ATVA '18/15, ICECCS '17, TIME '16, VSTTE '16, UTP '16, Sci. Comput. Program., Form. Asp. Comput., Nonlinear Anal.: Hybrid Syst., C. Zhou's Festschrift

HONORS & AWARDS

High-Impact Publication [12] in CS by Chinese Researchers across from Springer Nature	Feb. 2021
Nomination for the CAS Excellent Doctoral Dissertation Award [1]	Mar. 2020
CAS-President Special Award (1st awardee from ISCAS ever since its inception in 1985)	Jul. 2019
Best Paper Award [12] at FMAC 2019	Dec. 2019
Distinguished Paper Award [15] at ATVA 2018	Oct. 2018
National Scholarship	Oct. 2018/2010
Selected Attendee of the 6th Heidelberg Laureate Forum	Sep. 2018
Outstanding Student Award of UCAS Scientific Research Project	Dec. 2013

GRANTS

[PI] ZJU 100 Young Professor: Foundations of Cyber-Physical Systems	2023 - 2029
[PI] Qizhen Scholar: Talent program funded by ZJU Education Foundation	2023 - 2026
[Co-I] NSFC-61872341: Formal Verification of Delayed Dynamical and Hybrid Systems	2019 - 2022

SELECTED PUBLICATIONS   cf. page 5 for a complete list of publications

Inf. Com. Encoding Inductive Invariants as Barrier Certificates
Q. Wang, M. Chen✉, B. Xue, N. Zhan, and J.-P. Katoen
Information and Computation, 2022

CAV '22 Does a Program Yield the Right Distribution?
M. Chen✉, J.-P. Katoen, L. Klinkenberg, and T. Winkler
34th Int. Conf. on Computer Aided Verification (CAV 2022)

Acta Inf. Indecision and Delays Are the Parents of Failure
M. Chen✉, M. Fränzle, Y. Li, P. N. Mosaad, and N. Zhan
Acta Informatica, 2021

CAV '21 Latticed k-Induction with an Application to Probabilistic Programs
K. Batz, M. Chen✉, B. L. Kaminski, J.-P. Katoen, C. Matheja, and P. Schröer
33rd Int. Conf. on Computer Aided Verification (CAV 2021)

CAV '21 Synthesizing Invariant Barrier Certificates via Difference-of-Convex Programming
Q. Wang, M. Chen✉, B. Xue, N. Zhan, and J.-P. Katoen
33rd Int. Conf. on Computer Aided Verification (CAV 2021)

CAV '20 Unbounded-Time Safety Verification of Stochastic Differential Dynamics
S. Feng, M. Chen✉, B. Xue, S. Sankaranarayanan, and N. Zhan
32nd Int. Conf. on Computer Aided Verification (CAV 2020)

TACAS '20 Learning One-Clock Timed Automata   ♘ **Best Paper Award at FMAC 2019**
J. An, M. Chen, B. Zhan, N. Zhan, and M. Zhang
26th Int. Conf. on Tools and Algorithms for Construction and Analysis of Systems (TACAS 2020)

CAV '19 Taming Delays in Dynamical Systems
S. Feng, M. Chen✉, N. Zhan, M. Fränzle, and B. Xue
31st Int. Conf. on Computer Aided Verification (CAV 2019)

CADE '19	NIL: Learning Nonlinear Interpolants
	M. Chen✉, J. Wang, J. An, B. Zhan, D. Kapur, and N. Zhan
	27th Int. Conf. on Automated Deduction (CADE 2019)

ATVA '18	What's to Come Is Still Unsure 🎗 **Distinguished Paper Award**
	M. Chen✉, M. Fränzle, Y. Li, P. N. Mosaad, and N. Zhan
	16th Int. Symp. on Automated Technology for Verification and Analysis (ATVA 2018)

IEEE TAC	Reachability Analysis for Solvable Dynamical Systems
	T. Gan, M. Chen, Y. Li, B. Xia, and N. Zhan
	IEEE Trans. Automat. Contr., 2018

IJCAR '16	Interpolant Synthesis for Quadratic Polynomial Inequalities and Combination with *EUF*
	T. Gan, L. Dai, N. Zhan, D. Kapur, and M. Chen
	8th Int. Joint Conf. on Automated Reasoning (IJCAR 2016)

FM '16	Validated Simulation-Based Verification of Delayed Differential Dynamics
	M. Chen, M. Fränzle, Y. Li, P. N. Mosaad, and N. Zhan
	21st Int. Symp. on Formal Methods (FM 2016)

SELECTED TOOLS/PROTOTYPES

• KIPRO2: A tool that performs in parallel latticed k-induction and BMC to fully automatically verify upper bounds on expected values of possibly infinite-state probabilistic programs.

• **BMI-DC**: A prototype that proves unbounded-time safety of differential dynamical systems by synthesizing invariant barrier certificates via difference-of-convex programming.

• **NIL**: A learning-based tool that automatically synthesizes non-trivial (reverse) Craig interpolants for the quantifier-free theory of nonlinear arithmetic.

• **DGAME**: A tool that automatically synthesizes finite-memory controllers (a.k.a. winning strategies) for safety games under delayed information.

• **MPPS**: A procedure for deciding termination by computing the set of non-terminating inputs for multi-path polynomial programs with equality conditions.

• **MARS**: A toolchain for modelling, analyzing and verifying hybrid systems, which has been successfully applied in the verification of the Chinese lunar lander Chang'e-3 and the high-speed rail in China.

SELECTED TALKS

Dissertation Defence

• Verification & Synthesis of Time-Delayed Dynamics, *Doctoral Dissertation Defence at ISCAS*, Beijing, China, May 2019.

Tutorials

• Taming Delays in Cyber-Physical Systems, *ESWEEK*, Shanghai, China, Oct. 2022. [Tutorial co-presented with Naijun Zhan].

• Formal Analysis, Verification and Design of Safety-Critical CPS, *RTSS*, Houston, USA, Dec. 2020. [Tutorial co-presented with Lei Bu, Qixin Wang and Naijun Zhan].

Conferences, Workshops, Seminars & Visits

• Lower Bounds for Possibly Divergent Probabilistic Programs, *MOVES' Colloquium at Schloss Dagstuhl*, Saarbrücken, Germany, Apr. 2022 & *ROCKS*, Nijmegen, Netherlands, May 2022.

• Latticed k-Induction with an Application to Probabilistic Programs, *Information Sciences Seminar* & *Youth Forum*, *Peking University*, Beijing, China, Oct. 2021.

• Synthesizing Invariant Barrier Certificates via Difference-of-Convex Programming, *Seminar on Cyber-Physical Systems*, *University of Southampton*, Southampton, UK, Apr. 2021 & *CAV*, Los Angeles, USA, Jul. 2021.

- On ∞-Safety of Stochastic Differential Dynamics, *MOVES Seminar*, *RWTH Aachen University*, Aachen, Germany, Apr. 2020 & *CAV*, Los Angeles, USA, Jul. 2020.

- (In-)Variant Synthesis for Probabilistic Programs [Immature Idea], *MOVES' Winter Colloquium at Kleinwalsertal*, Kleinwalsertal, Austria, Feb. 2020.

- Interpolation over Nonlinear Arithmetic - Towards Program Reasoning and Verification, *PKU Seminar on Programming Languages*, *Peking University*, Beijing, China, Sep. 2019 & *MOVES Seminar*, *RWTH Aachen University*, Aachen, Germany, Nov. 2019 & *FACAS*, La Falda, Córdoba, Argentina, Mar. 2022.

- Taming Delays in Dynamical Systems - Unbounded Verification of Delay Differential Equations, *CAV*, New York City, USA, Jul. 2019.

- Modelling · Verification · Synthesis - A Peek into the Blueprint of Hybrid Systems, *RWTH Aachen University*, Aachen & *Technische Universität München*, München, Germany, Oct. 2018.

- What's to Come is Still Unsure - Synthesizing Controllers Resilient to Delayed Interaction, *ATVA*, Los Angeles, USA, Oct. 2018 & *CAP*, Beijing, China, Sep. 2018 & *MISSION@INVAP*, San Carlos de Bariloche, Argentina, Feb. 2022.

- Towards Delays in Dynamical and Control Systems - Verification & Synthesis, *Universität des Saarlandes*, Saarbrücken, Germany, Jul. 2016 & *LEDS*, Shanghai, China, Dec. 2016.

- Validated Simulation-Based Verification of Delayed Differential Dynamics, *FM*, Limassol, Cyprus, Nov. 2016.

- Computing Reachable Sets of Linear Vector Fields Revisited, *ECC*, Aalborg, Denmark, Jun. 2016.

- A Two-Way Path between Formal and Informal Design of Embedded Systems, *UTP* & *iFM*, Reykjavík, Iceland, Jun. 2016.

- HHL Prover: An Improved Interactive Theorem Prover for Hybrid Systems, *ICFEM*, Paris, France, Nov. 2015.

- Decidability of Reachability for a Family of Linear Vector Fields, *ATVA*, Shanghai, China, Oct. 2015.

VISITS & PARTICIPATIONS

Academic Visits

Hybrid Systems Group, C. v. Ossietzky Universität Oldenburg, Oldenburg, Germany   Fall, 2015 - 2018

Software Modeling and Verification Group, RWTH Aachen University, Aachen, Germany   Oct. 2018

Chair of Robotics, AI and Real-time Syst., Technische Universität München, München, Germany Oct. 2018

Dependable Systems and Software Group, Universität des Saarlandes, Saarbrücken, Germany   Jul. 2016

Conferences & Workshops

ESWEEK '22, ROCKS '22, FACAS '22, MISSION '22, RP '21, LPP '21, CPS-IoT Week '21, VSOW03 '21, CAV '21/20/19/17, RTSS '20, ETAPS '20, ATVA '18/15, HLF '18, CONFESTA '18, CAP '18/17, SETTA '17, FMAC '17/16, FM '16, ECC '16, iFM&UTP '16, LEDS '16/14, ICFEM '15, CDZ '14, SAVE '14

Summer/Autumn Schools

The Summer School on Formal Methods, Beijing, China   Aug. 2019/2018

The 3rd School on Engineering Trustworthy Software Systems, Chongqing, China   Apr. 2017

The 2nd AVACS Autumn School, Oldenburg, Germany   Oct. 2015

The 4th Summer School in Symbolic Computation, Beijing, China   Aug. 2015

The 5th Summer School on Formal Techniques, Atherton, CA, USA   May 2015

The 4th SAT/SMT Summer School, Semmering, Austria   Jul. 2014

TECHNICAL SKILLS

Programming Languages	C/C++, Python, Mathematica, Maple, Matlab/Simulink, LaTeX
Operating Systems	macOS, Unix/Linux, Windows (dedicated to video games)
Software Tools	ARCH toolset, ATP/ITP, model checkers, SDP solvers, algebra systems

Languages

English: working-language	German: for survival only	Chinese: mother-tongue

Complete List of Publications

Dissertation

[1] M. Chen⊠. Verification and synthesis of time-delayed dynamical systems. *PhD Dissertation*, Institute of Software, Chinese Academy of Sciences, China, 2019. [Nomination for the CAS Excellent Doctoral Dissertation Award].

Book Chapters

[2] M. Chen⊠, X. Han, T. Tang, S. Wang, M. Yang, N. Zhan, H. Zhao, and L. Zou. MARS: A toolchain for modelling, analysis and verification of hybrid systems. In *Provably Correct Systems*, pages 39–58. Springer, 2017.

Journal Articles

[3] Q. Wang, M. Chen⊠, B. Xue, N. Zhan, and J.-P. Katoen. Encoding inductive invariants as barrier certificates: Synthesis via difference-of-convex programming. *Inf. Comput.*, Special Issue on Formal Verification of Cyber-Physical Systems, 2022. To appear.

[4] M. Chen⊠, M. Fränzle, Y. Li, P. N. Mosaad, and N. Zhan. Indecision and delays are the parents of failure - Taming them algorithmically by synthesizing delay-resilient control. *Acta Informatica*, 58(5):497–528, 2021.

[5] J. Wang, J. An, M. Chen, N. Zhan, L. Wang, M. Zhang, and T. Gan. From model to implementation: A network-algorithm programming language. *Sci. China Inf. Sci.*, 63(7), 2020.

[6] M. Fränzle, M. Chen, and P. Kröger. In memory of Oded Maler: Automatic reachability analysis of hybrid-state automata. *ACM SIGLOG News*, 6(1):19–39, 2019.

[7] T. Gan, M. Chen, Y. Li, B. Xia, and N. Zhan. Reachability analysis for solvable dynamical systems. *IEEE Trans. Automat. Contr.*, 63(7):2003–2018, 2018.

Peer-Reviewed Conference Papers

[8] M. Chen⊠, J.-P. Katoen, L. Klinkenberg, and T. Winkler. Does a program yield the right distribution? Verifying probabilistic programs via generating functions. In *Proc. of CAV '22*, pages 79–101, 2022. [Arfifact Evaluated].

[9] Q. Wang, M. Chen⊠, B. Xue, N. Zhan, and J.-P. Katoen. Synthesizing invariant barrier certificates via difference-of-convex programming. In *Proc. of CAV '21*, pages 443–466, 2021. [Arfifact Evaluated].

[10] K. Batz, M. Chen⊠, B. L. Kaminski, J.-P. Katoen, C. Matheja, and P. Schröer. Latticed k-induction with an application to probabilistic programs. In *Proc. of CAV '21*, pages 524–549, 2021. [Arfifact Evaluated].

[11] S. Feng, M. Chen⊠, B. Xue, S. Sankaranarayanan, and N. Zhan. Unbounded-time safety verification of stochastic differential dynamics. In *Proc. of CAV '20*, pages 327–348, 2020. [Arfifact Evaluated].

[12] J. An, M. Chen, B. Zhan, N. Zhan, and M. Zhang. Learning one-clock timed automata. In *Proc. of TACAS '20*, pages 444–462, 2020. [Arfifact Evaluated · Best Paper Award at FMAC 2019].

[13] S. Feng, M. Chen⊠, N. Zhan, M. Fränzle, and B. Xue. Taming delays in dynamical systems - Unbounded verification of delay differential equations. In *Proc. of CAV '19*, pages 650–669, 2019. [Arfifact Evaluated].

[14] M. Chen⊠, J. Wang, J. An, B. Zhan, D. Kapur, and N. Zhan. NIL: Learning nonlinear interpolants. In *Proc. of CADE '19*, pages 178–196, 2019.

[15] M. Chen⊠, M. Fränzle, Y. Li, P. N. Mosaad, and N. Zhan. What's to come is still unsure - Synthesizing controllers resilient to delayed interaction. In *Proc. of ATVA '18*, pages 56–74, 2018. [Distinguished Paper Award].

[16] B. Xue, P. N. Mosaad, M. Fränzle, M. Chen, Y. Li, and N. Zhan. Safe over- and under-approximation of reachable sets for delay differential equations. In *Proc. of FORMATS '17*, pages 281–299, 2017.

[17] T. Gan, L. Dai, B. Xia, N. Zhan, D. Kapur, and M. Chen. Interpolant synthesis for quadratic polynomial inequalities and combination with *EUF*. In *Proc. of IJCAR '16*, pages 195–212, 2016.

[18] T. Gan, M. Chen, Y. Li, B. Xia, and N. Zhan. Computing reachable sets of linear vector fields revisited. In *Proc. of ECC '16*, pages 419–426, 2016.

[19] M. Chen, A. P. Ravn, S. Wang, M. Yang, and N. Zhan. A two-way path between formal and informal design of embedded systems. In *Proc. of UTP '16*, pages 65–92, 2016.

[20] M. Chen, M. Fränzle, Y. Li, P. N. Mosaad, and N. Zhan. Validated simulation-based verification of delayed differential dynamics. In *Proc. of FM '16*, pages 137–154, 2016.

[21] T. Gan, M. Chen, L. Dai, B. Xia, and N. Zhan. Decidability of the reachability for a family of linear vector fields. In *Proc. of ATVA '15*, pages 482–499, 2015.

Manuscripts under Review

[22] Z. Zhang, C. Yu, H. Huang, R. Chang, M. Chen, Q. Dai, W. Shen, Y. Zhao, and K. Ren. PA-Boot: A formally verified authentication protocol for multiprocessor secure boot. *IEEE Trans. Dependable Secure Comput.*, 2023. Under review.

[23] Y. Li, N. Zhan, M. Chen✉, H. Lu, G. Wu, and J.-P. Katoen. On termination of polynomial programs with equality conditions. 2022. Under submission.

[24] K. Batz, M. Chen✉, S. Junges, B. L. Kaminski, J.-P. Katoen, and C. Matheja. Probabilistic program verification via inductive synthesis of inductive invariants. 2022. Under submission.