EDWARD KIM

Webpage, Google Scholar
Address: Dept. of Computer Science. UNC-Chapel Hill, Chapel Hill, NC 27599-3175
Email: ehkim@cs.unc.edu

EDUCATION

The University of North Carolina at Chapel Hill **2019 -**
Graduate Student, Computer Science

The University of California at Berkeley **2013 - 2017**
B.A in Computer Science
B.A in Pure Mathematics
Awarded Honors in Mathematics

RESEARCH INTERESTS

Quantum Computation Theory: Topological Quantum Computation
Quantum Algebra and Topology
Quantum Information Theory
Quantum Complexity Theory

PUBLICATIONS

- Sanaz Sheikhi, **Edward Kim**, Stanley Bak, Parasara Sridhar Duggirala:
Testcase Generation for Autonomous Racing Vehicles Through Fuzz Testing Techniques
To be submitted to 2021 CPS-IOT Week

- Luca Geretti, Julien Alexandre dit Sandretto, Matthias Althoff, Luis Benet, Alexandre Chapoutot, Pieter Collins, Parasara Sridhar Duggirala, Marcelo Forets, **Edward Kim**, Uziel Linares, David P. Sanders, Christian Schilling, and Mark Wetzlinger:
ARCH-COMP21 Category Report: Continuous and Hybrid Systems with Nonlinear Dynamics
8th Int. Workshop on Applied Verification for Continuous and Hybrid Systems, 2021

- **Edward Kim**, Stanley Bak, Parasara Sridhar Duggirala:
Automatic Dynamic Parallelotope Bundles for Reachability Analysis of Nonlinear Systems
19th International Conference on Formal Modeling and Analysis of Timed Systems, 2021
(arXiv, Slides)

- **Edward Kim**, Parasara Sridhar Duggirala:
Kaa: A Python Implementation of Reachable Set Computation Using Bernstein Polynomials
7th Int. Workshop on Applied Verification for Continuous and Hybrid Systems, 2020
(Slides)

- Wei-Kai Lai, **Edward Kim**:
Some Inequalities Involving Geometric and Harmonic Means
International Mathematical Forum, Vol. 11, 2016, no. 4, 163-169

OTHER CONTRIBUTIONS

- Stanley Bak, **Edward Kim**, Parasara Sridhar Duggirala:
COVID Infection Prediction using CPS Formal Verification Methods
ACM SIGBED Blog, June 21, 2021. Link

EXPOSITIONS

(*)-WIP

- **Notes on the Fourier Analysis of Boolean Functions**
  A short survey on the Fourier Analysis of Boolean Functions with view towards the Linial-Mansour-Nisan Theorem written as the final project for the Boolean Function Complexity course (Duke CPS 590) Report
- **Random Local Quantum Circuits as Unitary 2-designs**
  An annotation and review of *Random quantum circuits are approximate 2-designs* by Aram W. Harrow and Richard A. Low. The final result of a directed reading conducted during the Spring 2020 semester. Report
- **The Schur-Weyl Duality in Quantum Information**
  An exposition of the Schur-Weyl Duality and its role in seminal proofs found in Quantum Information Theory from Quantum Data Compression to Recoupling Coefficients. The final project for Quantum Information Theory class (Duke PHYS 590). Report
- * **Quantum Expanders and their Applications**
  Lecture notes on the definitions of Quantum Expanders and their tensor-product counterparts with specific attention to applications in Quantum Information Theory. Applications include Hastings' study of the entanglement entropy of some gapped one-dimensional systems and quasirandom quantum channels. These notes are created to prepare for a reading group on QIT during the Spring 2022 semester. Proposal
- * **Unique Games Conjecture with connections to Quantum Complexity**
  Writing as a supplement to the Analysis on Boolean Functions class (Duke COMPSCI 590). An exposition on the Unique Games Conjecture, The PCP Theorem, and some connections to Quantum Complexity and Information. Specific attention is given to topics with overlaps in Hypercontractivity, Non-local Games, and the Quantum PCP Conjecture.

RELEVANT COURSE WORK

Mathematics:	Lie Groups, Smooth Manifolds, Measure Theory, Functional Analysis, Differential Geometry, Lie Algebras and their Representations, Homological Algebra, Commutative Algebra, Complex Analysis
Computer Science:	Quantum Algorithms and Computation, Quantum Information Theory, Analysis on Boolean Functions, Boolean Function Complexity, Computational Complexity Theory, Randomized Algorithms, Introduction to Cryptography

EXPERIENCE

University of North Carolina at Chapel Hill **2019 -**
Research Assistant
Providing research assistance to projects pertaining to the formal verification of safety properties of non-linear cyber-physical systems. Focusing on counter-example generation to aid practitioners in verifying the safety of their models.

- Created a tool called **Kaa** for the reachability of non-linear discrete dynamical systems using parallelotope bundles. Improved on existing tools for reachablility computation using these techniques.
- Used parallelotope-based reachability techniques to model COVID disease dynamics.
- Investigated applications of *fuzz testing* for generating testcases for autonomous racing vehicles.

SERVICES

UNC Cyber-Physical Systems Lunch **Spring 2021**
Organizer
Organized the Cyber-physical/Real-time Systems Lunch during the Spring 2020 semester. During the lunch, students and faculty involved in Autonomous Systems, Real-Time Systems, Cyber-physical Systems, and Formal Verification met to discuss research and present recently-published papers during an hour-long session each week.

PEDAGOGY

Calculus Tutor **2018**
Tutored Calculus to students at South Carolina State University. Stressed geometric intuition and visual approaches rather than rote memorization of formulae and concepts.

Programming Languages Tutor **2018**
Provided discussions for South Carolina State University Computer Science students attending summer courses. These discussions pertained to basic programming language concepts in the context of Python, Java, and C.

PROJECTS AND SOFTWARE [GITHUB]

Kaa (> 8000 lines, Python)
Software created to experiment with reachable set computations of discrete non-linear dynamical systems. The project was specifically created to understand the effectiveness of dynamically-reorienting parallelotope bundles on improving the quality of over-approximations of reachable sets. It is the first experimental software created to properly plot the evolution of these dynamic bundle strategies for practitioners to understand the efficacy of different bundle strategies. It significantly improved the usability of previously existing reachable set simulators using these techniques.

TDAGo (Python)
Python program to analyze Go games using Persistence Homology for Duke's Topological Data Analysis class. Used the evolution of persistence diagrams to detect topologically-significant features of games played between iterations of Google Deepmind's AlphaGo.
[Link to Report]

WORKSHOPS/CONFERENCES ATTENDED

QONFEST 2021 Paris **2021**
19th International Conference on Formal Modeling and Analysis of Timed Systems
Link to Program

8th Int. Workshop on Applied Verification for Continuous and Hybrid Systems **2021**
Link to Program

7th Int. Workshop on Applied Verification for Continuous and Hybrid Systems **2020**
Link to Program

Simons Institute for the Theory of Computation **2020**
Spring 2020 Workshop on Quantum Protocols: Testing & Quantum PCPs
Link to Workshop Description