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Zhenpeng Wang Ph.D. Student

Education

Department of Mathematics, The University of Hong Kong Hong Kong, China
Ph.D. in Mathematics 2024 - 2028 *(expected)*

- Advisor: Prof. Guangyue Han
- Research area: Algebraic Geometry Codes and Information Theory

Department of Mathematics, Lomonosov Moscow State University Moscow, Russia
B.S. in Computational Mathematics and Cybernetics 2020 - 2024

- GPA: 3.86/4.00, Rank: 1/75.

Publications

1. **Zhenpeng Wang, Alexey Nikitin**. On the integral equation obtained as a result of the closure of the third degree. *Journal of Operations Research and Optimization*, 2024.

Awards and Honors

- **Special Talent Training Program for Russia, Ukraine, and Belarus**
  awarded by the China Scholarship Council 2024.01

Skills

Languages: Chinese, English, Russian.

Mathematics courses: Analysis (Real analysis, Complex Analysis, Functional Analysis, Differential Equations), Algebra (Linear algebra, Advanced Algebra, Algebraic Topology, Algebraic Geometry, Galois theory), Probability, Computational Mathematics (Advanced Optimization, Numerical Methods) and Cybernetics

Programming: `Python`, `C`, `C++`, `C#`, `R`, `MATLAB`, `Haskell`, `Java`, `LaTeX`.

PROJECTS

Research on the Casas-Alvero Conjecture
Beijing Institute of Technology 2023.06 - 2024.06

- Background: The Casas-Alvero Conjecture states that if a polynomial over a field shares at least one common root with all its non-zero derivatives, then the polynomial must be of the form $(x-a)^n$ for some linear factor. Specifically, let f be a monic polynomial in one variable over the field of complex numbers, with degree $n > 0$. If for all $k = 1, \ldots, n-1$ there exists $a_k \in \mathbb{C}$ such that $f(a_k) = f^{(k)}(a_k) = 0$, then f is of the form $(x-a)^n$, where $a \in \mathbb{C}$.
- Objective: Our goal was to attempt to prove the Casas-Alvero Conjecture or address the gap identified in our advisor's paper concerning finite fields with certain characteristic restrictions. We translated this conjecture into a problem within the field of algebraic geometry, specifically focusing on the dimension of the algebraic set defined by the derivatives of the polynomial: if a polynomial and all its non-zero derivatives share a common root, then the dimension of the algebraic set defined by these derivative polynomials is 1.
- Actions: Proof of Hilbert's Nullstellensatz: We completed the proof of Hilbert's Nullstellensatz over both the complex field and finite fields. The proof involved starting from the correspondence between affine algebraic sets and ideals in polynomial rings, using properties of Noetherian rings and Hilbert's Basis Theorem, introducing the irreducibility of algebraic varieties, and ultimately proving the applicability of Hilbert's Nullstellensatz in general algebraically closed fields and finite fields.
- Application of the Combinatorial Nullstellensatz and Gröbner Bases: We also completed the application and generalization of the Combinatorial Nullstellensatz, Noether normalization, and Gröbner bases over the complex field and finite fields, participating in mathematical formula derivations in combinatorics and algebra.
- Results: While our research was successful over the complex field and finite fields with sufficiently large characteristics, we encountered a series of complex and challenging issues in finite fields with characteristics not meeting certain conditions. We are currently delving deeper into these issues for further exploration and resolution.

Research on Integral Equations Derived from Ternary Closure
Lomonosov Moscow State University 2023.09 - 2024.06

- Background: In mathematical biology, models describing population dynamics often appear in the form of differential equations. However, traditional differential equation models typically ignore the spatial distribution of individuals, assuming a uniform spatial distribution of the population. To address this issue, Ulf Dieckmann and Richard Law proposed a spatially structured biological community model that uses spatial moments to describe the dynamic behavior of populations.
- Objective: This project aimed to study a nonlinear integral equation describing a steady-state single-species biological community and solve its fixed-point problem by constructing a nonlinear integral operator generated by the equation. This would determine the existence and uniqueness of solutions to the equation.
- Actions: Defined and explained mathematical symbols and model construction methods, introduced spatial moments to simplify research, constructed a nonlinear integral operator for a steady-state single-species community, proved the existence and uniqueness of fixed points, and validated theoretical results using numerical methods such as the Neumann series.
- Results: By constructing and analyzing the nonlinear integral operator, this project demonstrated that the nonlinear integral equation describing a steady-state single-species biological community has a unique solution under specific conditions. This provides a new research method and tool for the field of mathematical biology. Additionally, the research results offer theoretical support for addressing population dynamics in actual biological communities.
- Project Highlights: Systematically addressed the issue of spatial heterogeneity overlooked by traditional models.Proposed new mathematical tools and methods, laying a solid foundation for future research.Successfully applied numerical methods to validate theoretical results, enhancing the credibility of the research.

INTERNSHIPS **Shenzhen Labert Technology and Culture Co., Ltd.** | China 2023.01 - 2023.06

- Path Planning Algorithm Design: Utilizing the theories of topology and homology, design path planning algorithms suitable for six-legged robots to navigate in complex and dynamic environments. This includes identifying the topological structure and obstacles in the environment, analyzing possible paths of the robot through computing homology groups, and selecting the optimal path.
- Dynamic Environment Path Adjustment: In dynamic environments, update the robot's topological map in real-time and recalculate paths based on environmental changes to ensure efficient and safe navigation, avoiding obstacles and reaching the target location.
- Using Convex Analysis and Convex Optimization Methods to Solve Constraint Optimization Problems in Path Planning:Modeling Constraint Optimization Problems: Model the path planning problem as an optimization problem with constraints, utilizing convex analysis techniques to ensure problem solvability and the existence of optimal solutions.Implementation of Optimization Algorithms: Implement path planning algorithms based on convex optimization methods, using numerical methods and optimization tools (such as Matlab) to find the optimal path for the robot while satisfying constraints such as dynamics, energy consumption, and time.Algorithm Performance Optimization: By adjusting the parameters of the optimization algorithm, improve the convergence speed and solution accuracy, allowing the six-legged robot to quickly and efficiently plan paths in complex environments.
- Path Planning and Navigation System Simulation and Testing:Building Simulation Environments: Use Matlab and other simulation tools to construct path planning and navigation simulation environments for six-legged robots. Test the effectiveness and robustness of the algorithm by simulating complex terrains and dynamic obstacles.Algorithm Testing and Validation: Validate the performance of the path planning algorithm in different environments through the simulation platform. Analyze the algorithm's performance in handling dynamic changes, obstacle avoidance capability, and path optimization to ensure its feasibility and reliability in practical applications.