Xinying (Cindy) Ren, Ph.D.

Control Engineer · Synthetic Biologist

rxinying@gmail.com (+86)18621343721

https://www.researchgate.net/profile/Xinying-Ren

Education

2015 – 2021 **Ph.D. Control and Dynamical Systems, California Institute of Technology**, USA.
Thesis title: *Principles for Designing Robust and Stable Synthetic Microbial Consortia.*

2011 – 2015 **B.E. Automatic Control, Tsinghua University**, China.

2013 – 2014 **Exchange Student. Electrical Engineering and Information Technology, Technical University of Munich**, Germany.

Research Interest

synthetic&systems biology, molecular programming, biological networks, developmental circuits, control theory, complex systems, computational mathematics, dynamic programming algorithms.

Research Experience

2015 – 2021 **Research Assistant, California Institute of Technology**, USA.
Advisor: *Richard M. Murray*. Department: *Computational and Mathematical Sciences*.
Collaborator: *Michael Elowitz, Niles Pierce, John Doyle, Elisa Franco*.
My research lies in the interdisciplinary field of control systems, synthetic biocircuits and large-scale computation.
In my thesis, I developed multi-scale design principles of synthetic circuits using feedback control and distributed control theory to achieve stable and roust microbial consortia in spatially structured environments. These design principles require multi-scale engineering from single-cell level, population level to multi-species level, including rewiring gene regulatory network, engineering cell-cell signaling systems and interfering with cell-environment interactions. Three novel design principles are: 1) Signal Integral Feedback Control, which applies an integral feedback controller at population level via cell-cell communication, 2) State Switching Feedback Control, where a high-gain feedback controller emerges in a population from distributed decision making processes in individual cells, 3) Multi-layered Feedback Control, which fast adapts to small yet frequent disturbances like intracellular noises and robustly adapts to drastic yet less frequent disturbances from environments like nutrient shock, under tradeoffs between speed and cost.
I designed, engineered and tested these control circuits in *Escherichia coli* that achieve stable and robust cell population density and ratio using AHL-mediated quorum sensing systems. A collaborated work with the Elowitz lab implemented the control circuit in *CHO* cells using Auxin-meditated signaling systems to regulate population fraction. By mechanistic modeling and large-scale computation, the control circuits are shown to increase multi-species coexistence stability in spatially structured environments, relieve metabolic burden and promote evolutionary robustness of engineered microbial consortia.

Research Experience (continued)

2021 – 2023 **Post-doctoral Research Fellow, California Institute of Technology**, USA.
Advisor: *Richard M. Murray*, Collaborator: *Aaron Ames*.
I proposed a mathematical and algorithmic framework based on Gaussian Process to verify and validate hierarchical models with nested structures for multi-agent systems with applications in self-driving cars, legged robots and synthetic biological circuits.
I also worked on developing modeling and computation tools that are programmed for simulating and analysing spatial-temporal dynamics of cell populations (e.g. BioCRNpyler, Population-FSP, GRO).

Teaching Experience

2021.06 **Mentor of Caltech's WAVE Fellows project**.
Title: *Optimization of Spatially Engineered Microbial Consortia in Bacteria Powered Biobatteries*.

2020.01 **Teaching Instructor, BE 240 Open Source Tools for Biological Circuit Design**, Caltech.

2019.06 **Mentor of Caltech's SURF Fewllows project**.
Title: *Modeling and Analysis on Robust Synthetic Consortia with Localized Functions*.

2018.12 **Teaching Assistant, CDS 112 Optimal Control and Estimation**, Caltech.
Professor: *Soon-Jo Chung*.

Publications

1. X. Ren, C. C. Samaniego, R. M. Murray, and E. Franco, "Bistable state switch enables ultrasensitive feedback control in heterogeneous microbial populations," in *2021 American Control Conference (ACC)*, IEEE, 2021, pp. 652–659.
2. X. Ren and R. M. Murray, "Layered feedback control improves robust functionality across heterogeneous cell populations," *BioRxiv*, pp. 2020–03, 2020.
3. L. N. Green, C. Y. Hu, X. Ren, and R. M. Murray, "Bacterial controller aided wound healing: A case study in dynamical population controller design," *BioRxiv*, p. 659 714, 2019.
4. X. Ren and R. M. Murray, "Cooperation enhances robustness of coexistence in spatially structured consortia," in *2019 18th European Control Conference (ECC)*, IEEE, 2019, pp. 2651–2656.
5. X. Ren and R. M. Murray, "Role of interaction network topology in controlling microbial population in consortia," in *2018 IEEE Conference on Decision and Control (CDC)*, IEEE, 2018, pp. 2691–2697.
6. X. Ren, A.-A. Baetica, A. Swaminathan, and R. M. Murray, "Population regulation in microbial consortia using dual feedback control," in *2017 IEEE Conference on Decision and Control (CDC)*, IEEE, 2017, pp. 5341–5347.
7. Y. Yuan, X. Ren, Z. Xie, and X. Wang, "A quantitative understanding of microrna-mediated competing endogenous rna regulation," *Quantitative Biology*, vol. 4, pp. 47–57, 2016.

Presentations

2020.02 The 7th Winter Q-bio (Quantitative Biology) Conference. Oral talk.

2018.02 The 5th Winter Q-bio (Quantitative Biology) Conference. Oral talk.

2017.10 The 33rd Southern California Control Workshop. Invited session.

Presentations (continued)

2013.09 iGEM World Championship Jamboree. Asia Gold Medal.

Skills

Python, Matlab, R, C++, LaTeX, 3G assembly, bacterial culture.

References

Richard M. Murray, Ph.D.
Professor, Control and Dynamical Systems,
California Institute of Technology,
Email: murray@cds.caltech.edu.

John C. Doyle, Ph.D.
Professor, Control and Dynamical Systems,
California Institute of Technology,
Email: doyle@caltech.edu.

Michael B. Elowitz, Ph.D.
Professor, Biology and Bioengineering,
California Institute of Technology,
Email: melowitz@caltech.edu.

Elisa Franco, Ph.D.
Professor, Mechanical and Aerospace Engineering and Bioengineering,
University of California at Los Angeles,
Email: efranco@seas.ucla.edu.