Writing Successful NSF CAREER Proposals

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Associate Professor

Industrial Engineering & Management

Oklahoma State University

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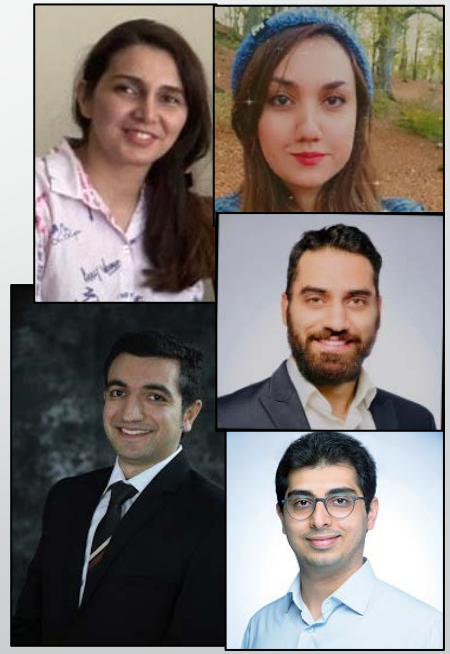
My Academic Background

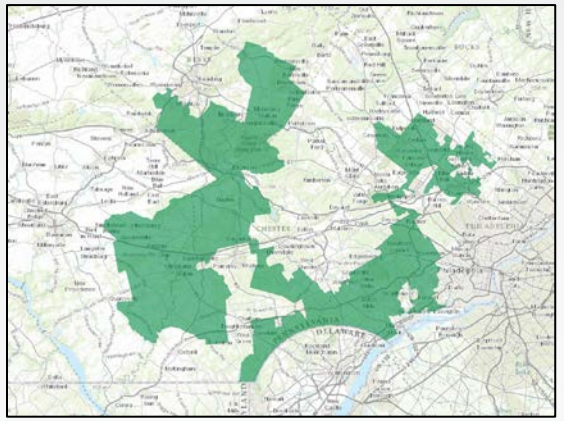
BS IEM (2007-2011)

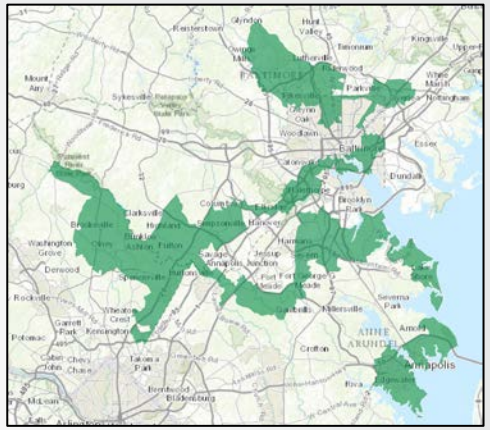
PhD ISE (2011-2015)



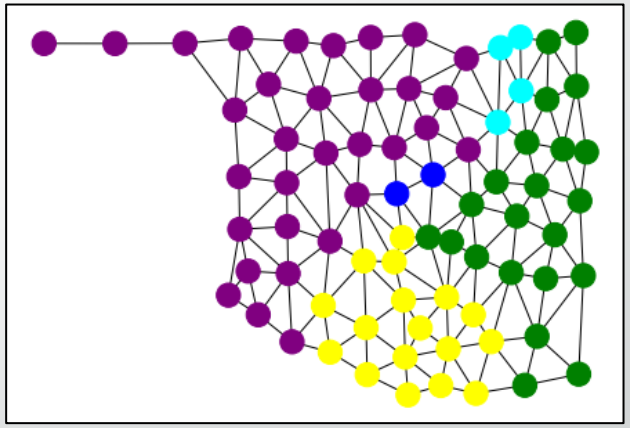
Assistant Prof (2015-2021)
Associate Prof (2021-now)

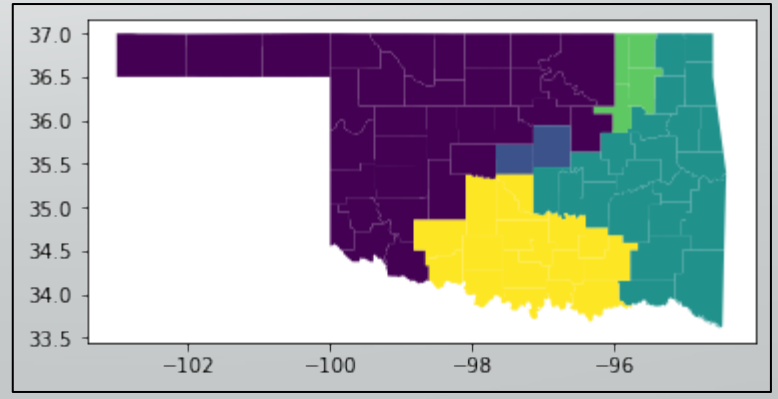
My Research Area





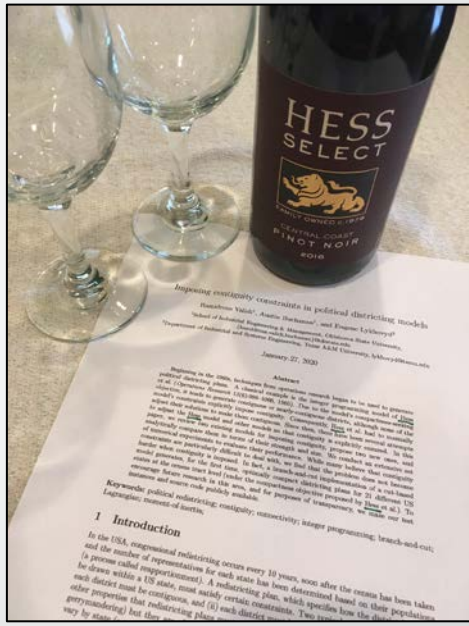
- Applications:
  - Political redistricting
  - Problems with connectivity/contiguity constraints
  - Problems with distance/compactness/latency constraints
  - Problems relating to clustering and cluster detection
- Methodology:
  - Integer programming; graphs; networks; polyhedral combinatorics; combinatorial optimization; …





My NSF CAREER Timeline

- 2013, Interest in districting due to connectivity constraints; read papers
- 2015, Mentioned districting in job talks
- 2017, Roped Hamid and Eugene into districting (at INFORMS Houston?)
- 2018,
  - Began weekly districting meetings with Hamid and Eugene
  - Read LOTS of districting papers, surveys, books
  - Shared proposal draft with coworker Baski
  - Submitted CAREER proposal (1st attempt)
  - Hired NSF REU summer researcher to work on Oklahoma redistricting
- 2019,
  - Met with OE Program Manager and discussed revision plan
  - Moon Duchin invites Hamid and AB to Voting Rights Data Institute
  - Shared revised proposal with coworker Baski
  - Resubmitted CAREER proposal (2nd attempt) –> SUCCESS!
- 2020-2025, NSF CAREER: Parsimonious Models for Redistricting



Tip 1: Perfect your 1-Page Overview

1 Overview and Objectives

In the past decade, gerrymandering has come under increasing scrutiny in the US. Common criticisms of allegedly gerrymandered maps include unequal district populations, a lack of contiguity or compactness, the needless splitting of counties (or other political subdivisions), or the "cracking and packing" of racial minorities or members of a particular political party. This leads to questions about baselines and tradeoffs: What is the most compact redistricting plan? How few counties must be split? Is a minority sufficiently numerous and compact to require a "majority-minority" district under the Voting Rights Act? To what extent do constraints on redistricting plans restrain would-be gerrymanderers? To answer these questions, one must solve optimization problems that are beyond the reach of existing techniques. This is largely a consequence of three facts. First, redistricting plans must satisfy rigid equal-population constraints, meaning that one must allow for counties (or other units) to be split into multiple districts. This leads to very large problem instances with up to 1 million indivisible census blocks (denoted by n henceforth). Second, existing optimization models for redistricting suffer from a large number of variables, $\Omega(n^2)$. Third, existing models neglect to impose contiguity, or do so in a way that does not scale well. Thus, there is a *critical need* to develop improved techniques for redistricting. *In the absence of such techniques, the public will continue to lack the computational tools necessary to know the true limits of gerrymandering, the effectiveness of traditional countermeasures, and their unintended consequences.*

Our *long-term goal* is to develop theory and computational methods for solving large-scale network design problems that have distance, latency, or compactness constraints. Our *overall objective* in the proposed study is to develop improved exact techniques for redistricting. Our *central hypothesis* is that new formulations can be used to solve redistricting instances at a significantly finer scale than exact techniques currently allow, through reformulations that exploit planarity or through decomposition methods. We have formulated this hypothesis, in part, based on the PI's recent theoretical work on spanning tree formulations in planar graphs, which can be extended for redistricting purposes. The resulting $O(n)$-variable *Arborescence* model is promising, in part because its LP relaxation can be solved on a desktop computer, even at the block level. Such a feat is impossible with a direct application of previous formulations, since they require nearly 1 trillion variables. Additionally, in preliminary work with decomposition methods, the PI has generated an optimally compact congressional redistricting plan for Indiana at the tract level ($n = 1511$)—significantly larger than any instance solved by an exact method in the literature.

The proposed research is *creative and original* because it proposes and experiments with the first optimization models for redistricting that use only $O(n)$ variables and thus have the potential to be tractable at the finest level of granularity possible given US Census data. It is anticipated that the *expected outcome*—computationally viable methods for districting—will (i) provide nonpartisan procedures for districting that can provide a starting point for developing implementable districting plans, and (ii) further inform the public about the possible dangers to the democratic process that can arise when redistricters have the twin powers of big data and big computation. Furthermore, the techniques developed as part of this proposal can be adapted for sales districting [13] and home-care districting [15]. Thus, the proposed research may *positively impact* the public and private sectors.

As part of the education plan, the PI will develop redistricting modules for operations research (OR) and integer programming (IP) courses. These modules will be piloted at OSU, shared with colleagues at other universities, and then shared publicly. In the PI's courses, projects on redistricting will be assigned and used to identify promising undergraduates, particularly women and underrepresented minorities, for participation in REUs. Finally, the PI will organize an inter-university challenge on OR methods for redistricting. Included in the budget is travel support for 1st place to attend the INFORMS Annual Meeting and compete for the Undergraduate OR Prize.

Tip 2: Write for a Broad Audience

CAREER: Advancing Theory and Practice of Robust Simulation Analysis Under Input Model Risk
Award Number:2045400; Principal Investigator:Eunhye Song; Co-Principal Investigator:; Organization:Pennsylvania State Univ Univ

CAREER: An Adaptive Stochastic Look-ahead Framework for Disaster Relief Logistics under Forecast Uncertainty
Award Number:2045744; Principal Investigator:Yongjia Song; Co-Principal Investigator:; Organization:Clemson University;NSF Orga

CAREER: Catastrophic Rare Events: Theory of Heavy Tails and Applications
Award Number:2146530; Principal Investigator:Chang-Han Rhee; Co-Principal Investigator:; Organization:Northwestern University;

CAREER: Consumer Behavior-Aware Learning for Revenue Management
Award Number:1846792; Principal Investigator:Shipra Agrawal; Co-Principal Investigator:; Organization:Columbia University;NSF O

CAREER: Data-driven dynamic adaptive optimization for next generation power system operation
Award Number:1751747; Principal Investigator:Xu Sun; Co-Principal Investigator:; Organization:Georgia Tech Research Corporation

CAREER: Data-Driven Personalized Chronic Disease Management
Award Number:1847666; Principal Investigator:Anil Aswani; Co-Principal Investigator:; Organization:University of California-Berkele

CAREER: Design of Matching Markets
Award Number:1653477; Principal Investigator:Yashodhan Kanoria; Co-Principal Investigator:; Organization:Columbia University;NS

CAREER: Distribution Resource Elasticity: A New Hierarchical Approach for On-Demand Distribution Platforms
Award Number:1751801; Principal Investigator:Jennifer Pazour; Co-Principal Investigator:; Organization:Rensselaer Polytechnic Inst

CAREER: Domain-aware Statistical Learning
Award Number:2143695; Principal Investigator:Xiao Liu; Co-Principal Investigator:; Organization:University of Arkansas;NSF Organ

CAREER: Enhancing E-Commerce and Service Systems by Embracing Consumer Flexibility
Award Number:1944428; Principal Investigator:Adam Elmachtoub; Co-Principal Investigator:; Organization:Columbia University;NS

CAREER: Enhancing Environmental and Economic Sustainability of Additive Manufacturing-based Remanufacturing
Award Number:1943985; Principal Investigator:Yisha Xiang; Co-Principal Investigator:; Organization:Texas Tech University;NSF Org

CAREER: Favorable Optimization under Distributional Distortions: Frameworks, Algorithms, and Applications
Award Number:2046426; Principal Investigator:Weijun Xie; Co-Principal Investigator:; Organization:Virginia Polytechnic Institute an

CAREER: From the Cloud to the Crowd: An Enabling Solution for the Internet of Federated Things
Award Number:2144147; Principal Investigator:Raed Al Kontar; Co-Principal Investigator:; Organization:Regents of the University o

CAREER: Harnessing Prediction Engines and Non-Monetary Mechanisms for Real-Time Decision Making
Award Number:1847393; Principal Investigator:Siddhartha Banerjee; Co-Principal Investigator:; Organization:Cornell University;NS

CAREER: Hierarchical Commit or Defer Problems with Learning: Methods and Applications
Award Number:2145553; Principal Investigator:Juan Borrero; Co-Principal Investigator:; Organization:Oklahoma State University;N

CAREER: Improving Operational Decision Making with Predictive Information and Data
Award Number:1944209; Principal Investigator:Jing Dong; Co-Principal Investigator:; Organization:Columbia University;NSF Organi

CAREER: Improving Service Systems through Real-time and Delayed Information
Award Number:1751975; Principal Investigator:Jamol Pender; Co-Principal Investigator:; Organization:Cornell University;NSF Organ

CAREER: Innovative Methods for Designing Adaptive Clinical Trials
Award Number:1651912; Principal Investigator:Amin Khademi; Co-Principal Investigator:; Organization:Clemson University;NSF Or

CAREER: Integrative Resource Optimization Framework for Large-scale Drone Delivery Systems
Award Number:1944068; Principal Investigator:Yanchao Liu; Co-Principal Investigator:; Organization:Wayne State University;NSF O

CAREER: LEarning to Search with Structure (LESS), a Unifying Algorithmic Framework for Gray Box Optimization of Bio
Award Number:2046588; Principal Investigator:Giulia Pedrielli; Co-Principal Investigator:; Organization:Arizona State University;NS

CAREER: Marketplace Design for Freight Transportation and Logistics Platforms
Award Number:2145661; Principal Investigator:He Wang; Co-Principal Investigator:; Organization:Georgia Tech Research Corporatio

CAREER: Methods for Data-Driven Service Engineering
Award Number:2143752; Principal Investigator:Harsha Honnappa; Co-Principal Investigator:; Organization:Purdue University;NSF O

Tip 3: Make a Revision Plan

PI: Austin Buchanan | Title: CAREER: Parsimonious Models for Redistricting

Major Comments	Plan
1. The proposal did not cite all the relevant literature in the area	• Cite poli sci work by Altman, Arrington, Bullock, Duchin, Polsby-Popper, Young, etc • Cite heuristics (sometimes Lagrangian-based) by Altman, Beasley, Bozkaya, Hojati, Jacobson, etc
2. A preliminary computational comparison is lacking. The proposal makes very bold statements, that may being overstretching the reality of the potential contribution.	Include two experimental results tables: • LP solve times for Hess model, tract level • IP solve times for Hess+Shirabe model, as compared to current work
3. The PI did not demonstrate knowledge of relevant objective functions.	• Explicit section on objective functions from OR literature, poli-sci literature, reform groups • Emphasize importance of basic objective functions as foundation, studied in isolation for best insights.

4. The PI did not have any existing collaborations with domain experts that were documented in the proposal or associated letters.	Seek "advisory board" of districting experts for guidance on objective functions, modeling aspects, validation, and analysis (VRA checks).
	
	Candidates for collaboration letters include:
	• Micah Altman (MIT)
	  ○ Cited by SCOTUS
	  ○ Brookings
	  ○ Boards of various polisci associations
	  ○ BARD, Public Mapping Project, District Builder
	• Moon Duchin (Tufts)
	  ○ Founder of Metric Geometry and Gerrymandering Group (MGGG)
	  ○ Co-host of Voting Rights Data Institute, where my student will spend 6 weeks
	  ○ Witness/wrote Amicus brief in recent NC case before SCOTUS

5. The panel had concerns about the use of funding for competition awards.	Three options: • Keep as is. Discuss with PM? • Drop cash prize, but keep travel support. • Drop both cash prize and travel support.
6. Complaints about (i) Education plan for grad students, (ii) implicitness of integration plan, and (iii) evaluation and assessment of educational activities.	• Add districting project to IP course • Give integration plan its own section • Work with ITLE to develop strong educational assessment plan, with a technique/strategy for each activity