Emeritus Promotion

Garrison Greenwood

Career Highlights

Career Highlights

- Graduated California State Polytechnic University, Pomona BSEEE, 1976
  - Tau Beta Pi
- Graduated California State Polytechnic University, Pomona, ME, 1979
  - Eta Kappa Nu
- Graduated University of Washington, PhD EE, 1993

- Naval Weapons Station, Seal Beach, CA 1976-1981
- Boeing Corp. 1981-1082
- Eldec Corp. 1986-1987
- Sundstrand Data Control 1987-1990
- Voice Computer Corp. 1990-1992
- Space Labs Medical, Inc. 1992-1993

- Western Michigan University, Associate Professor, ECE Department, 1993-1999
- Portland State University 2000-present
- Visiting Professor, University of New South Wales, Canberra, Australia (2013)

- Registered Professional Engineer in State of California (Electrical Engineering)

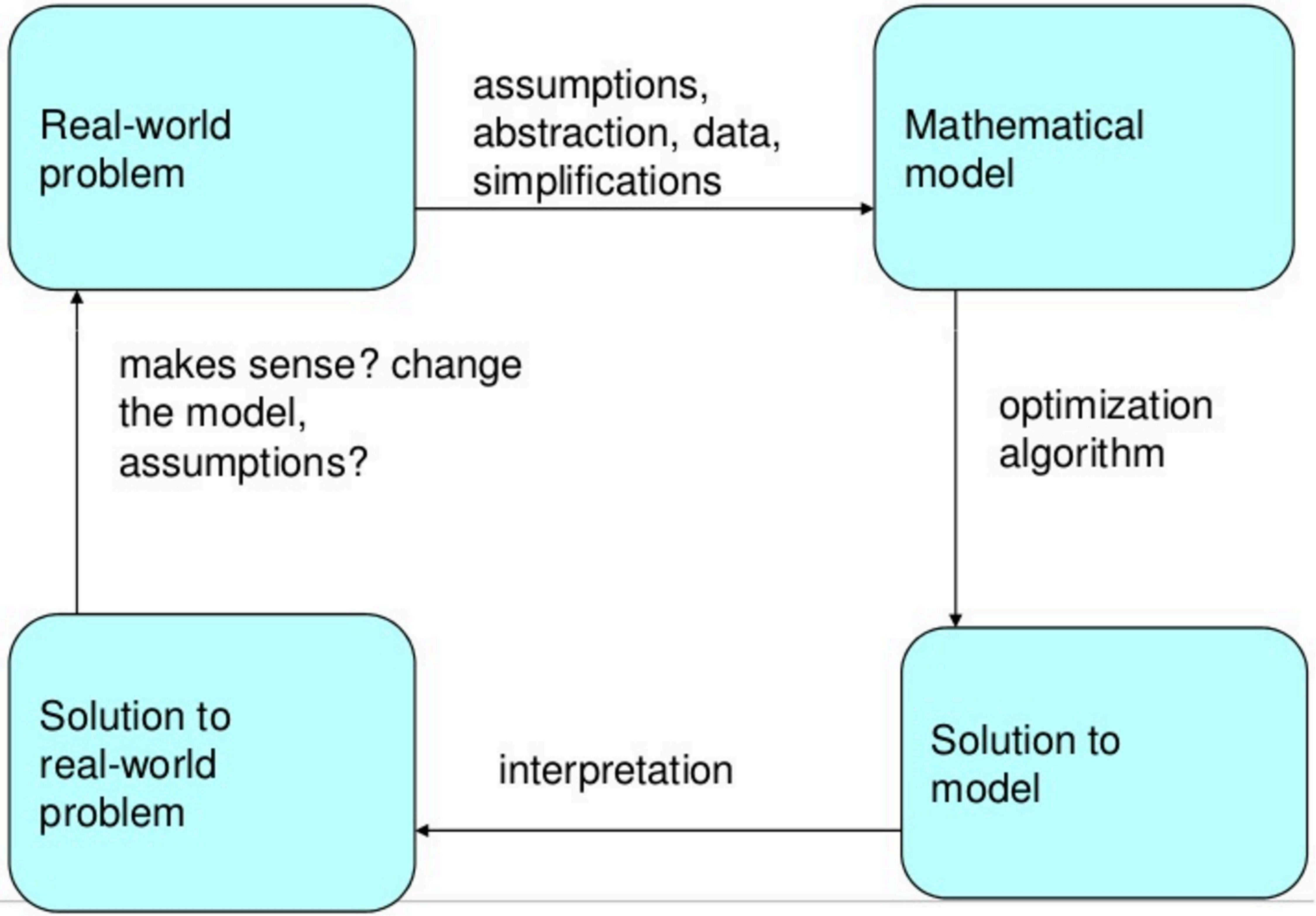
Research

Optimization is a process that tries to identify the best alternative or problem solution possibly subject to a set of one or more constraints.

Why is optimization necessary?

- minimize effort
- save time
- reduce costs & errors
- improved efficiency

A schematic view of modeling/optimization process



Real-world optimization problems are essentially search problems

You have to visit 10 cities on a sales trip. What order should you visit the cities to minimize the total distance traveled?

How should standard cells be placed in a floorplan to minimize the total area and interconnect cost?

American Airlines needs to schedule aircraft into one of its maintenance facilities. How should these aircraft be scheduled to minimize the downtime?

What is the 3-D structure of a protein?

So how do you find the best solution?

Could enumerate all possible solutions and then pick the best one.

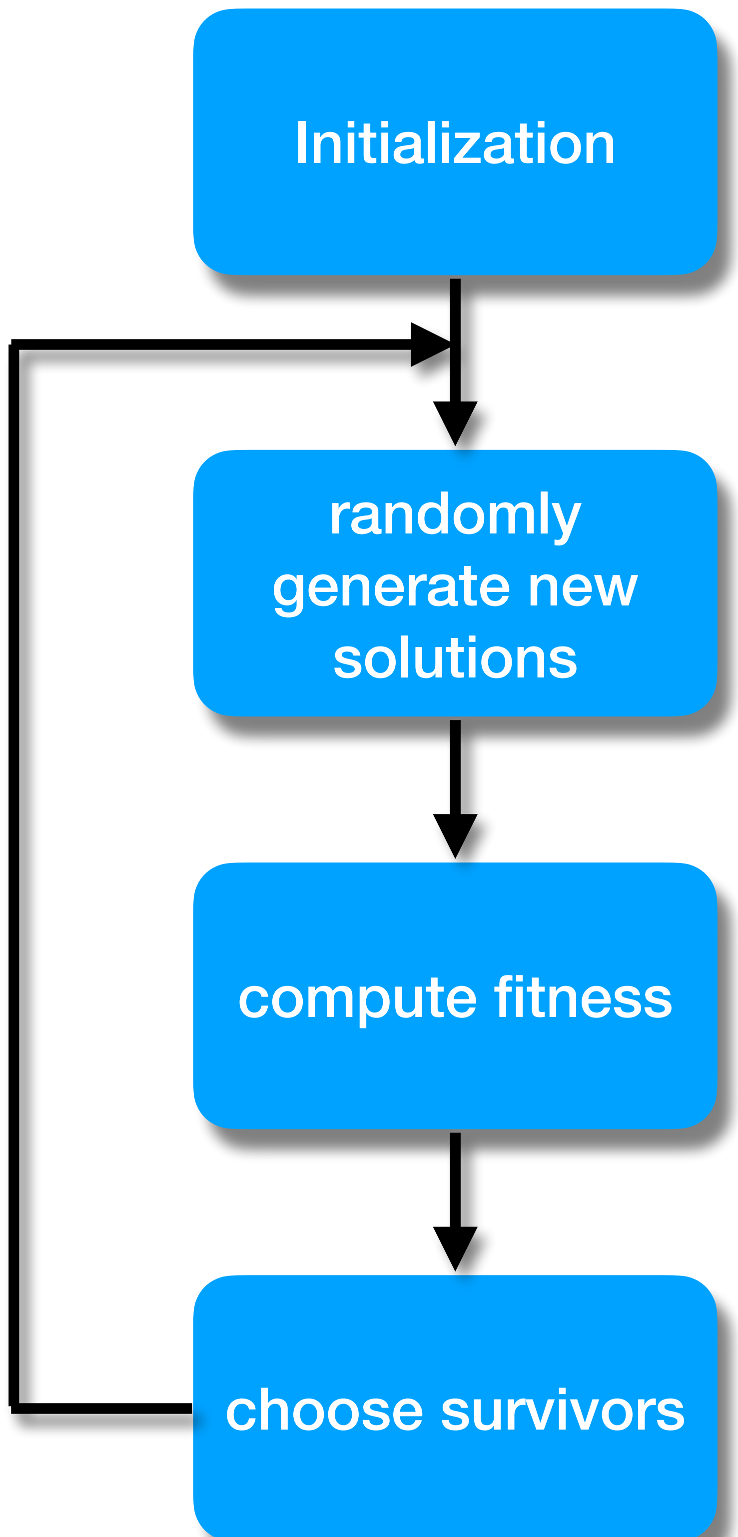
Unfortunately, that isn't practical because the number of potential solutions is too large.

For example, in the 10 city traveling salesman problem there are $10! \approx 3.6$ million possible tours!!

This has given rise to stochastic search algorithms that search the solution space probabilistically

- Monte Carlo methods
- evolutionary algorithms

Evolutionary algorithms mimic neo-darwinistic dynamics (survival of the fittest) found in nature.



randomly generate a set of solutions

stochastic operations (e.g., mutation) generate new solutions

metric to determine how good the solutions are

choose which ones to keep and which ones to discard

The optimization problems evolutionary algorithms can find good solutions for is virtually limitless

- code breaking (mathematics)
- distributed computer network topologies (computing)
- estimation of heat flux between the atmosphere and sea ice (earth sciences)
- water resource system design (environment)
- real options valuation (finance, game theory)
- optimal control (automotive, aerospace systems)
- vehicle routing (transportation)
- building phylogenetic trees, gene expression profiling (biological sciences)
- neural network design (general)
- wireless sensor network design (cyberphysical systems)
- …

Plus they can handle all kinds of optimization problems

- combinatorial optimization
- continuous optimization
- multi-objective optimization
- dynamic optimization

My research focuses on optimization in two main areas:

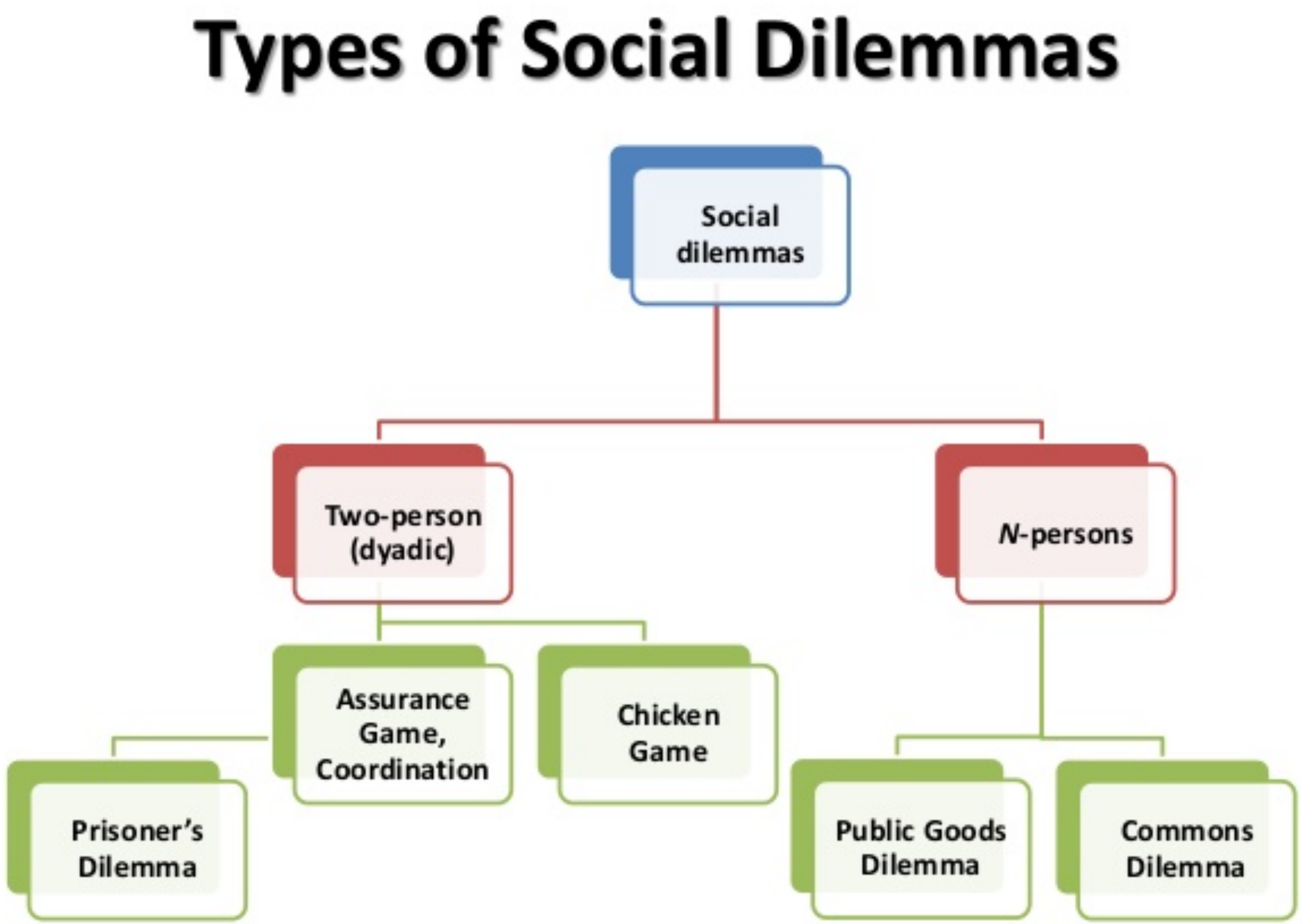
* Evolutionary game theory
* Cyber-Physical Systems

Evolutionary Game Theory

Game theory studies the interaction of agents in competitive environments.

Evolutionary Game Theory (EGT) studies populations of repeatedly interacting agents and tries to determine how agent strategies evolve over time.

Social dilemmas are situations where individuals must decide to act in the interest of the group (cooperation) or in their own self-interest (defection).



Social dilemmas have two conflicting properties:

(1) the individual does best by defecting regardless of what others do

(2) the group does best if everyone cooperates—-in particular, even better than when everyone defects

The Public Goods Game (PGG)

$N > 2$ players simultaneously decide whether or not to contribute \$1 to a common pool. Cooperators contribute the \$1; defectors contribute nothing.

The amount in the pool is multiplied by a factor of $1 < r < N$. This larger pot is then equally distributed amongst the N players—even to those who contributed nothing.

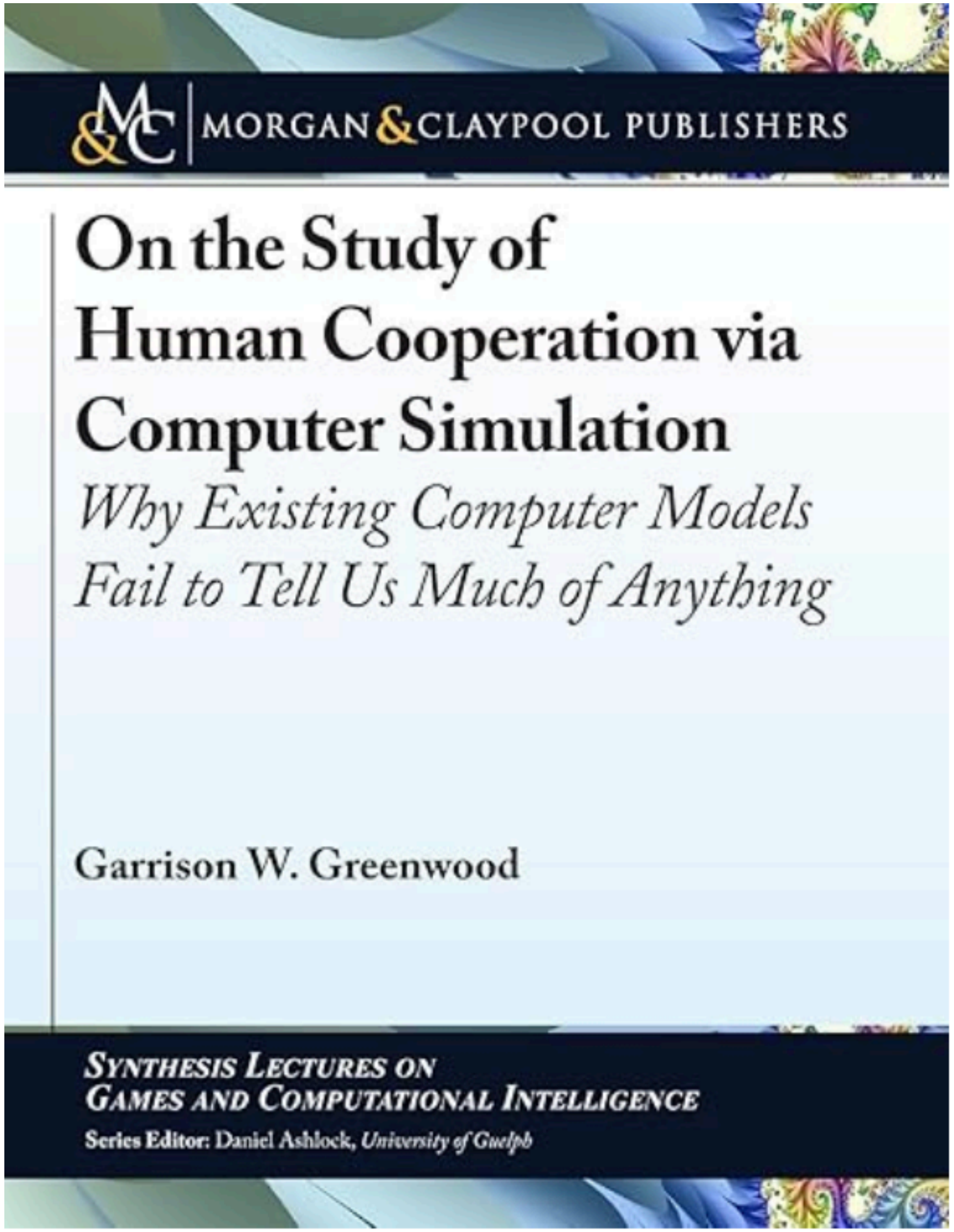
Players who contributed must subtract their \$1 contribution from their return. Thus defectors always do better than cooperators.

But if everyone defects, then everybody loses....

Many real-world social dilemmas can be modeled as a PGG. Examples include

- public land usage (e.g., parks or bike paths)
- participation in climate change fund programs
- funding national defense
- environmental policies
- funding fire & police services
- ....

Property taxes pay for fire protection & EMS. Everyone benefits regardless of whether or not they pay property taxes. But if nobody paid property taxes, how would this protection be funded?



Since coming to PSU I have published 1 book, 6 journal papers and 24 conference papers in this topic area.

Significant contributions

- Evolved strategies for participants in climate change fund programs. Interviewed by UK reporter after journal publication.

- Introduced tag mediation to study group migration in public goods games. Model exhibits characteristics found in human experiments.

- Recent studies indicate emotions play a significant role in how people make decisions in social dilemmas. (Human experiments indicate guilt and anger drive strategy choices in PGG experiments.)

- First use of fuzzy logic to model emotions of individuals in social dilemmas. Model duplicated human experimental results.

New Initiatives in Evolutionary Game Theory

Along with a colleague at the University of Guelph, we have shown it is possible for fairness to evolve in an N-player ultimatum game.

But, this evolution does not consider individual player decisions and therefore provides no real insight into the human decision making process.

Goal: Develop methods for studying individual player decision making in N-player ultimatum games.

Two promising approaches: ***self-adaption*** and ***Monte Carlo Tree Search*** as a machine learning mechanism

Cyber-Physical Systems

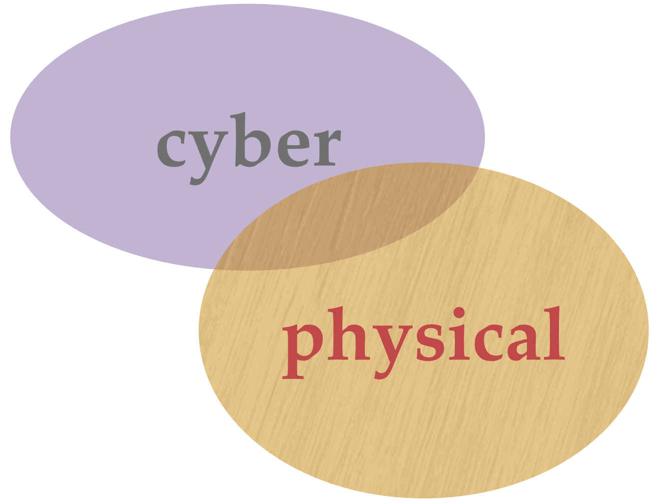
Def. (*cyber-physical system*)

A system where the computer resources, networking and physical processes are tightly integrated together.

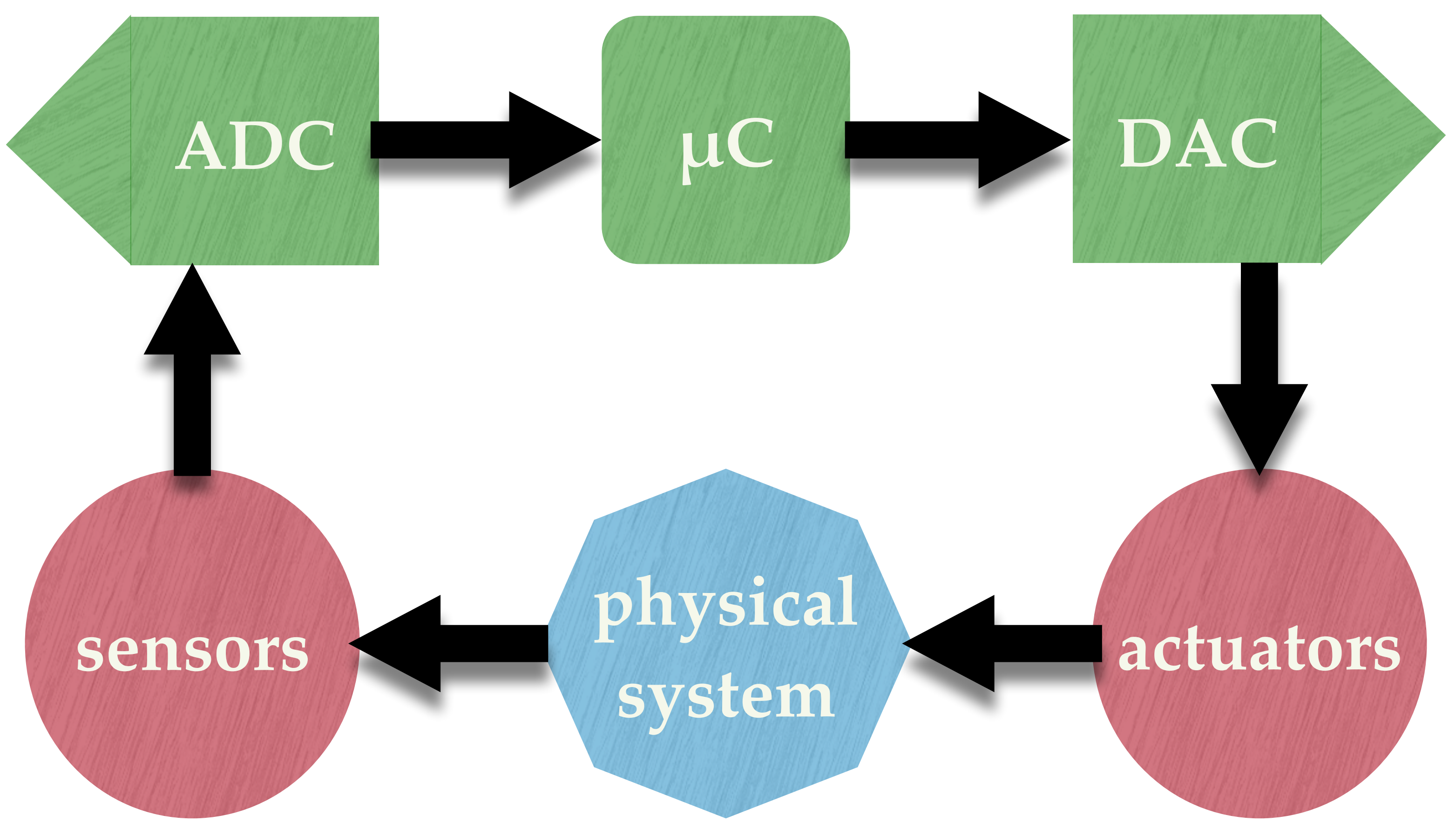
In a cyber-physical system (CPS), computer systems and communication networks—i.e., the "cyber"—monitor and control a physical system—i.e., the "physical".

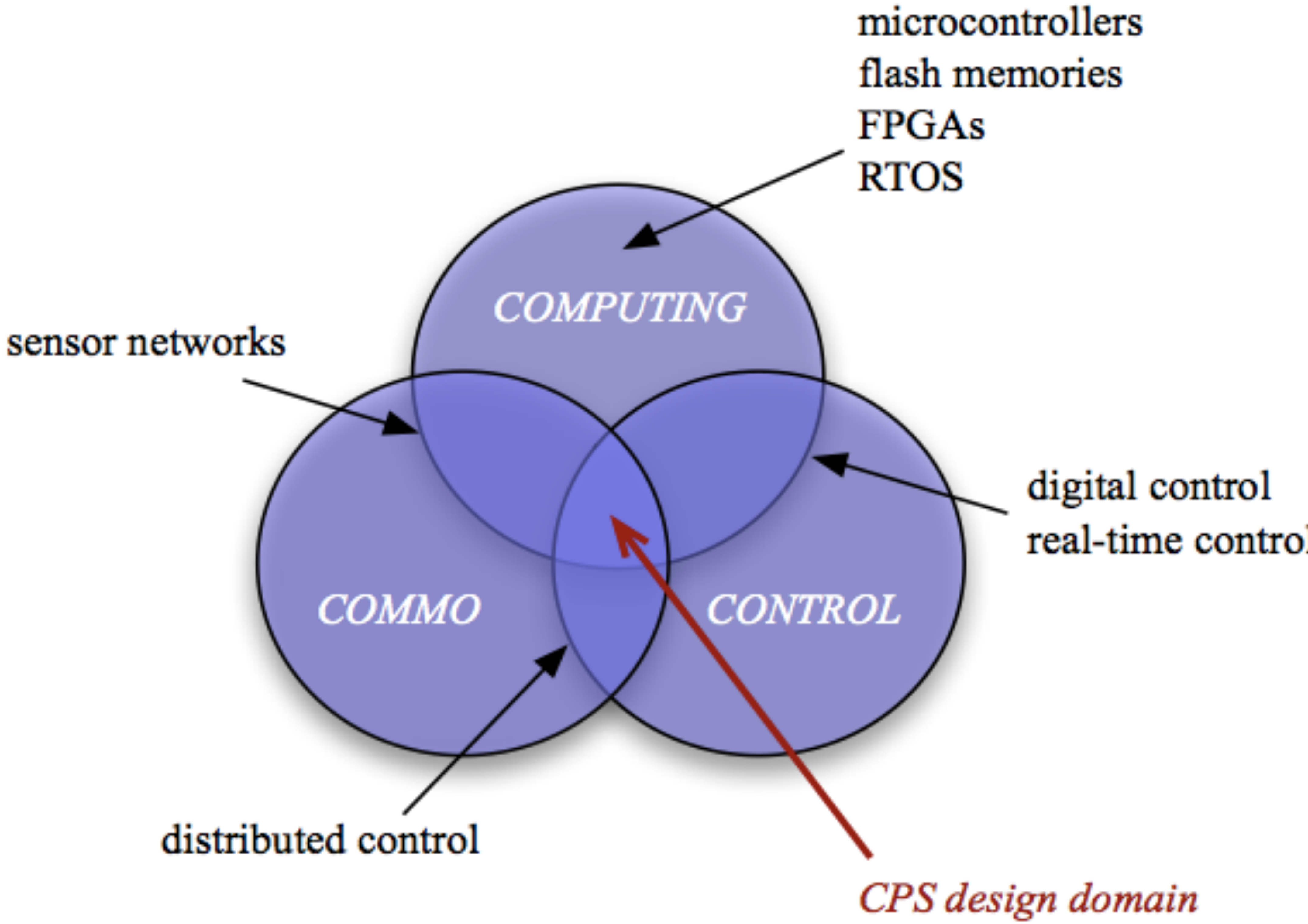
In a true CPS this integration is so tight it will not be possible to say what is the source of observed behavior.

CPS involves the intersection—*not the union*—of the physical and the cyber.



A CPS can be thought of as a set of embedded devices that are networked to sense, monitor, and control the physical world.




microcontrollers
flash memories
FPGAs
RTOS
COMPUTING
sensor networks
digital control
real-time control
COMMO
CONTROL
distributed control
CPS design domain

One particular area of my interest is in **fault-tolerant** CPSs.

These systems can continue operation (albeit, perhaps with degraded behavior) despite hardware failures

In such systems, fault detection and fault recovery must occur **autonomously**, eliminating any need for on-site human involvement.

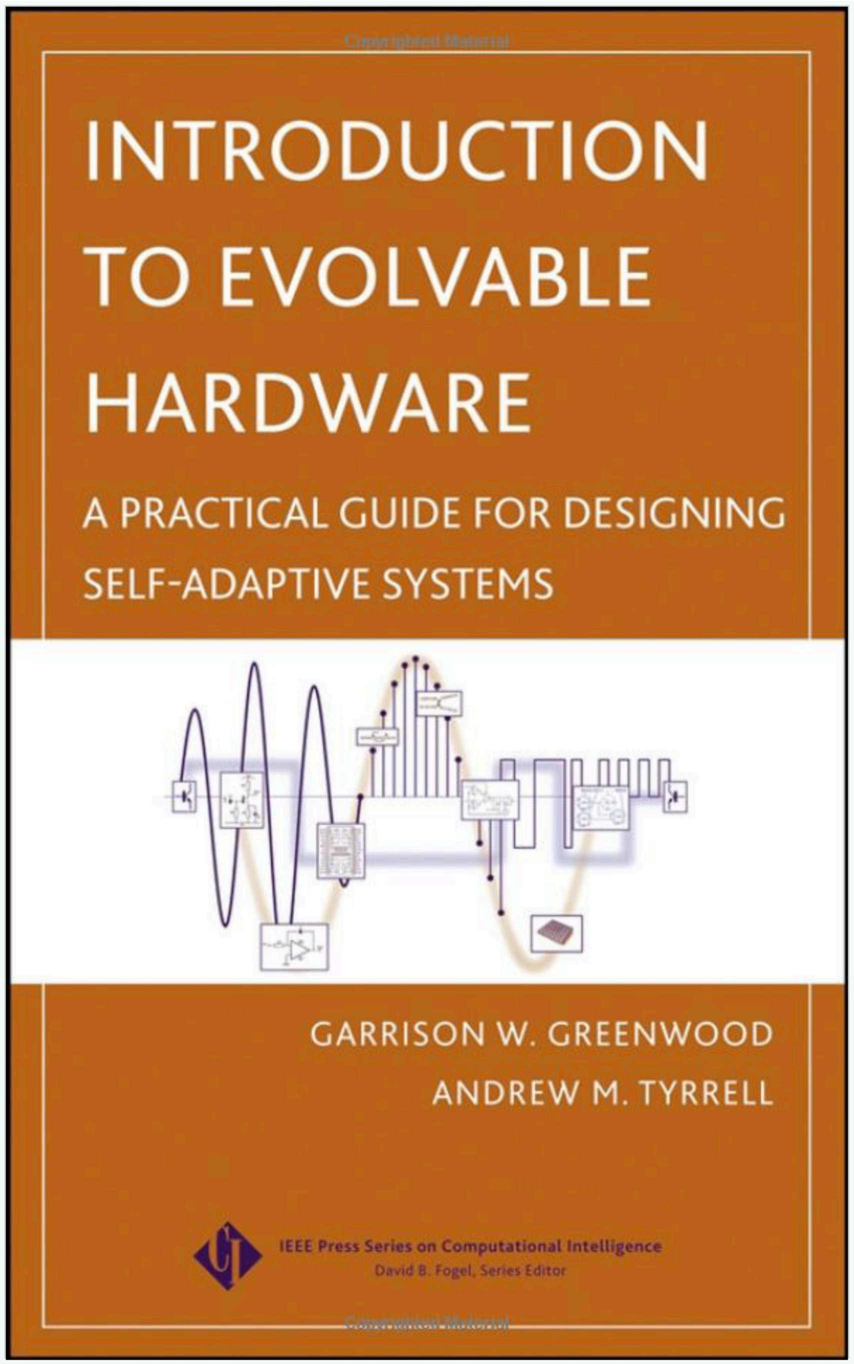
Evolvable/adaptive Hardware

Evolvable hardware uses evolutionary algorithms to design and/or adapt the behavior of engineering systems. Much more than just searching for good component values; the computer algorithms can also search for circuit configurations.

For example, an engineer wants to design a linear quadratic regulator (LQR) controller for a feedback control system. An evolutionary algorithm could certainly design the controller. But what if a LQR controller is not the ideal choice? What if you didn't know some other type of controller would be better?

Evolvable hardware techniques can explore other types of controller configurations and help find the optimal choice

Since coming to PSU I have authored/co-authored 1 book, 2 book chapters, 3 journal papers and more than 15 conference papers in this topic area.



200 citations

Significant contributions

- Demonstrated autonomous self-adaption in analog circuitry
- Introduced the metamorphic system architecture (extended evolvable hardware techniques to mechanical systems)
- First use of evolutionary algorithms to design test pattern sets for signal integrity checking in high-speed buses
- Used evolutionary algorithms to design a fault tolerant controller for a flapping-wing micro air vehicle.

New Initiatives in Evolvable/Adaptive Hardware

Next area of investigation involves fault tolerance in safety-critical cyberphysical systems.

Fault tolerant systems have two functions: (1) ***fault detection and isolation*** (FDI), and (2) ***fault recovery*** (FR)

Fault recovery is not new in CPS research, but everybody tends to focus on FR; the FDI aspect has been virtually ignored.

Approach: CPS monitors its performance as a background task. Recorded data is input to a machine learning (ML) system.

Goal: Develop ML-based fault detection method capable of detecting subtle system problems that have long-term, catastrophic consequences if left untreated.

CPS publications include:

- Flapping wing UAV controller design
- using evolvable hardware methods in CPS design
- self-organization of wireless sensor networks for wildfire detection in remote areas

Conf. paper under review:

Fault recovery for a class of unmanned autonomous vehicles using gaussian process regression

Research Funding

Funded Reseach

Funding agency:	NSF
Title:	**Cyber-Physical Systems: Methodologies for Engineering with Plug-and-Learn Components: Formal Synthesis and Analysis Across Abstraction Layers**
My role:	Co-PI
Funded amount:	$1,000,000 ($310,000 to PSU)
Duration:	09/2012–09/2017

Funding agency:	(subcontract to) University of Missouri
Title:	**Forward Looking Landmine and Explosive Hazard Detection**
My role:	PI
Funded amount:	$39,788
Duration:	06/2009–06/2011

Funding agency:	NASA
Title:	**Characterizing Genetic Algorithms for Real-Time Adaptive Systems**
My role:	PI
Funded amount:	$13,500
Duration:	01/2002–06/2002

Funding agency:	PSU Faculty Enhancement Program
Title:	**Data Envelopment Analysis Into Evolutionary Algorithms**
My role:	Co-PI
Funded amount:	$10,000
Duration:	06/2001–08/2001

Submitted (not funded)

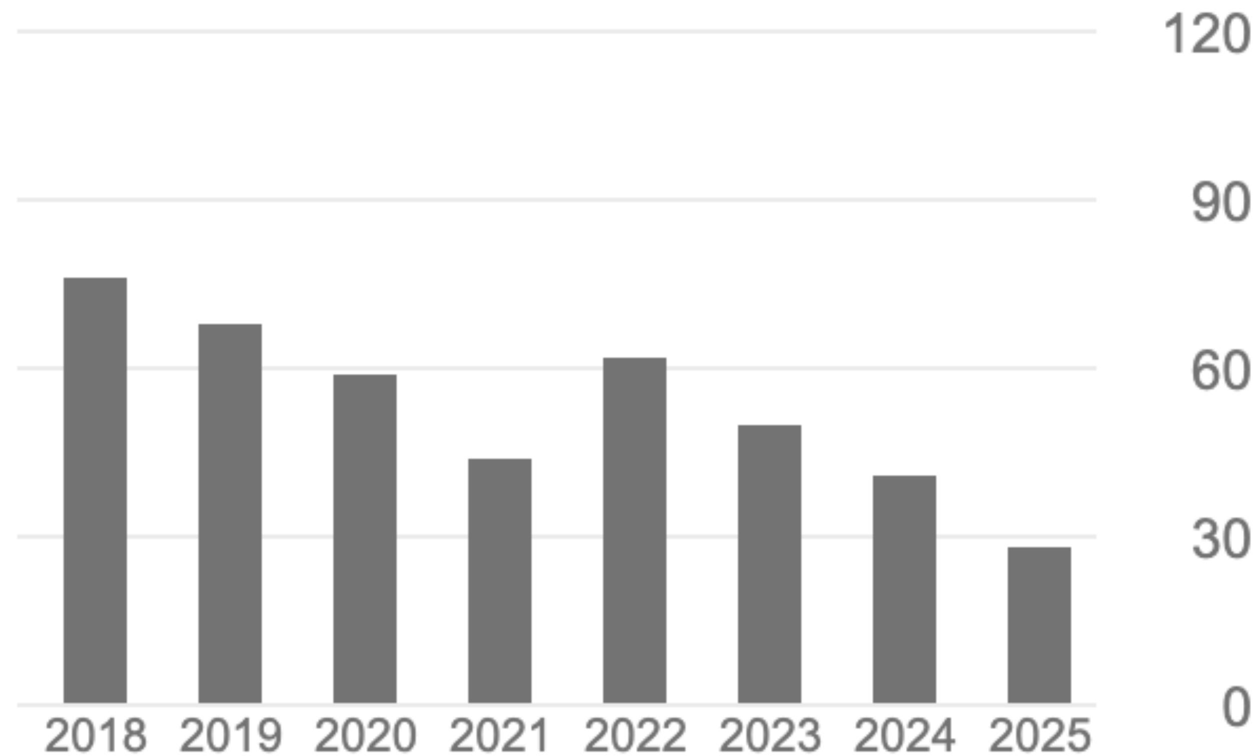
NSF	2202302	CPS: Small: Using Bayesian Optimization for Fault Recovery in a Class of Cyber-Physical Systems	Withdrawn	$115,313
NSF	2204531	A Bayesian Approach for Fault Recovery in a Class of Autonomous Systems	Declined	$115,313
NSF	1757237	Emotion Modeling for Decision Making in Social Dilemmas	Declined	$106,297
NSF	1657660	Emotions and Their Role in Decision Making in Social Dilemmas	Declined	$103,993
NSF	1202358	Adaptive Control for Autonomous Nonlinear Systems	Declined	$279,512
NSF	1068073	Autonomous Adaptive Control of Non-Linear Systems	Declined	$152,315
NSF	1023129	Adapting Behavior in Autonomous Nonlinear Systems via Control Strategy Replacement	Declined	$146,655
NSF	1016210	Mimicking Army Ant Swarm Raids to Help Solve Global Optimization Problems	Declined	$113,739
NSF	0854679	Imitating Army Ant Swarm Raids to Search Large Continuous Spaces for Global Optima	Declined	$125,086
NSF	0756110	Mimicking Army Ant Swarm Raids to Search Large Continuous Spaces for Global Optima	Declined	$122,124
NSF	0705624	Mimicking Army Ant Swarm Raids to Search Large Continuous Spaces for Global Optima	Declined	$64,088
NSF	0652362	Adaptive Strategies for Improved Survivability	Declined	$214,362
NSF	0551874	Modeling Insect Behavior to Find Low Energy Atomic Cluster Configurations	Declined	$361,555
NSF	0520752	A Study of Eigenstructure and Synthesis of Unitary Operators	Declined	$64,352
NSF	0456079	Unitary Operators and Quantum Computing: A Study of Operator Eigenstructure	Declined	$64,068
NSF	0426284	A Framework for Analyzing Structure in Unitary Operators	Declined	$48,055
NSF	0310626	Evolving Test Patterns for Predicting Power Consumption in IP Cores	Declined	$211,914
NSF	0305256	A Framework for Conducting Eigenanalysis on Unitary Operators Used in Quantum Optimization Algorithms	Declined	$45,653
NSF	0204172	A Preference-Based Search Methodology for VLSI Physical Design Optimization Problems	Declined	$435,455
NSF	0203135	A New Design Automation Tool That Evolves Test Patterns for Predicting Power Dissipation in Core-Based Designs	Declined	$200,100
NSF	0112390	A New Design Automation Tool That Evolves Test Patterns for Power Consumption Prediction in Core-Based Designs	Declined	$199,986
NSF	0110620	Reducing Power Consumption in Embedded Systems By Intelligent Linking	Declined	$47,910
NSF	0090045	A Macroevolutionary Model for Short-term Extinction Effect Prediction	Declined	$84,282
NSF	0082882	ITR/ACS: Evolutionary Algorithms for Electronic Structures and Conformations of Clusters	Declined	$394,602
NSF	0071609	Evolving Test Patterns for Parameter Prediction and QA Test	Declined	$1,266,443

Publications

Publication Statistics

Type	Quantity
Journal Papers	36
Conference Papers	91
Books	2
Book Chapters	5

	All	Since 2020
Citations	1853	285
h-index	22	7
i10-index	43	6



Notes:
1. 134 total publications
2. All pubs peer-reviewed
3. Books published 2006 and 2022
4. 19 Journal pubs are sole-author

Teaching

Teaching

- Undergraduate teaching: ECE 171, 172, 315, 317, 351, 424
- Graduate teaching: ECE 530, ECE 559, ECE 584
- Have taught PSU ECE undergraduate courses in Shanghai and Changchun, China and Da Nang, Vietnam

Teaching

- Course Development
  - ECE 315 (Signals and Systems I)[1,2]
  - ECE 351 (Verilog and FPGA Design)[2]
  - ECE 530 (Fault Tolerant Systems)
  - ECE 559 (Genetic Algorithms)
  - ECE 584 (Foundations of Cyberphysical Systems)

[1] originally ECE 312 (Fourier Analysis)

[2] required course

Student Advising

Student Advising

- Graduated Ph.D. students
  1. S. Hutsell (2009)
  2. M. Podhradsky (2017)
- Graduated M.S. Students
  1. S. Chopra
  2. C. Jorgensen
  3. J. Makarand
  4. P. Tomson
  5. D. Sharook
- Undergraduate Honors Program

  J. Anderson

- ETA KAPPA NU Faculty Advisor (2000-2002)

University Service

University Service

- Department Committees (P&T 3 times, etc.)
- Faculty search committees
- Staff search committees (Dept. Manager, Office Staff)
- Department Graduate Program Director (2005-2012)
- Faculty marshal at annual PSU June Commencement (10 years)
- University Academically Controlled Auxiliary Activities Fund Committee (2010)
- University Student Conduct Committee (2017–2023)
- Faculty Senate (2022-2025)

Community Outreach

Community Outreach

- Served as judge for Intel's science fair
- Interviewed by a reporter in the UK concerning my findings published in a journal paper relating to climate change
- Technical consultant for the law firm of Esler, Stephens & Buckley, Portland, OR

Professional Service

Professional Service

- Served on more than 40 research conference organizing comittees (technical co-chair, special sessions chair, etc.)
- General Chair, IEEE Congress on Evolutionary Computation Conference (2004, 2012)
- Editorial Board Member, *Games* (2023-present)
- Editor-in-Chief, *IEEE Transactions on Evolutionary Computation* (2009-2014)
- IEEE Computational Intelligence Society
    - Vice-President (conferences) 2006-2009
    - member, Technical Committee on Evolutionary Computation (2005-2017)
    - member, Technical Committee on Games (2015—2019)
    - member, Task Force on Ethics in Computational Intelligence (2017—2018)

Professional Service

- Reviewer
  - IEEE Transactions on Evolutionary Computation (2000—)
  - IEEE Transactions on Artificial Intelligence & Computation in Games* (2015—)
  - IEEE Transactions on Emerging Topics in Computational Intelligence (2017—)
  - Evolvable Hardware & Genetic Programming (2009—)
- NSF Review Proposal Review Panels
  - Evolutionary Computation (2009)
  - Integrative Graduate Education & Research Traineeship Program (IGERT, 2011)
  - Cyberphysical System Breakthrough High Confidence & Design (2014)
- Australian Research Council Proposal Review Panel (2011, 2012, 2018)

* renamed IEEE Transactions on Games effective Jan 2018

Professional Service

- Invited Talks & Tutorials
  - Tutorial (Intro to game theory), 2014 IEEE Conf. on Computational Intelligence and Games, Dortmund, Germany
  - Invited talks
    - University of Queensland
    - RMIT
    - Victoria University of Wellington
    - National University of Singapore
    - University of Missouri
    - International Workshop on Nature Inspired Computation & Applications, Hefei, China

Memberships

Memberships

- Senior member, IEEE
- Lifetime member, Tau Beta Pi
- Lifetime member, Eta Kappa Nu
- Member, Sigma Xi