Evolving Robust and Reconfigurable Multi-objective Controllers for Advanced Power Systems

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AADI
Autonomous Agents and Distributed Intelligence

NETL Crosscutting Research Review
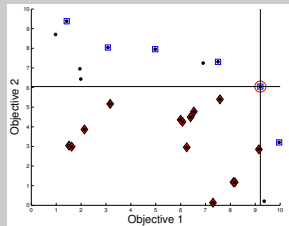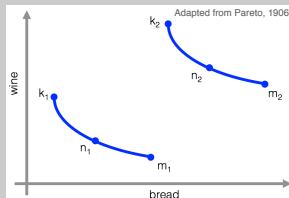
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Problem

Control in Complex Systems

- Many state-of-the-art methods depend on an accurate system model
- System models can be difficult to obtain
- System models are accurate only in a small operating range
- Controls actively change the environment
  - Highly dynamic
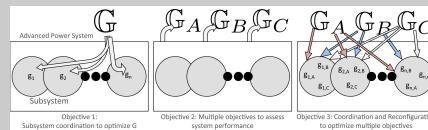 - Highly coupled
  - Feedback loops

Multi-Objective Problems

- Optimizing two or more quantities simultaneously

- A scalar problem becomes a vector problem

- Pareto Optimality

- Dominance

Adapted from Pareto, 1906

The Big Picture

Project Objectives

Objective 1: Subsystem coordination to optimize G
Objective 2: Multiple objectives to assess system performance
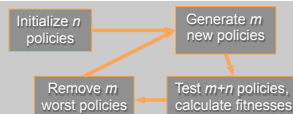Objective 3: Coordination and Reconfiguration to optimize multiple objectives

- Objective 1: Demonstrate robust and scalable bio-mimetic control of an Advanced Power System
- Objective 2: Demonstrate ability of controller to ensure multiple objectives are satisfied by Advanced Power System
- Objective 3: Demonstrate robust reconfigurability of controller in response to changing requirements of the Advanced Power System

Evolving Controllers

- Requires no direct model
- Generates a population of solutions
- Robust to noisy systems, poor system models

Initialize n policies → Generate m new policies → Test $m+n$ policies, calculate fitnesses → Remove m worst policies

Solution Concept: PaCcET

- Distort underlying "objective space" to allow simple linear combinations to discover complex Pareto Fronts
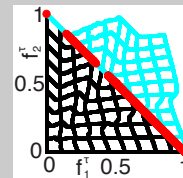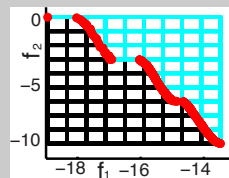

Benefits

Parallel Heat Exchanger: Heat Imbalanace

- Heat exchanger cost rises exponentially to their size: parallel is cheaper

- Balancing the heat flow between the parallel exchangers is a challenging control problem

- Population-based search creates a set of policies that trade off performance on different objectives

- Robust, reconfigurable control of complex power system components

Reconfigurability
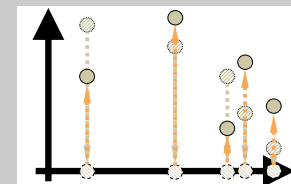
- Changing Power System requirements necessitates new sets of control policies on demand
- Pareto Optimal set of solutions may change