Development of Integrated Biomimetic Framework with Intelligent Monitoring, Cognition, and Decision Capabilities for Control of Advanced Energy Plants

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Challenges in Modern Control
- Fast changing and highly interacting process dynamics
- Operation under large number of constraints with evolving boundary
- Agile plant operation quickly adapting to changing requirements
- Short-term vs long term operational objectives
- Highly conflicting control objectives – profit vs environmental performance vs equipment life vs plant availability

Biomimetic Control Structure Selection
- Dynamically change the control structure to achieve the changing control objective without violating process and environmental constraints
- Exploits the functional specialization and integration that characterizes the cortical/sub-cortical areas of human brain
- Utilize information about connection strength and architecture for a specific stimulation
- Self-organization of the control structure that mimics the function of the cortical areas of human brain
- Dynamics switching between SISO, SIMO, MISO, and MIMO configurations
- Distributed and adaptive controllers that mimic the rule of pursuit present in ants
- Intelligent monitoring, cognition, and decision capabilities that mimic the immune system
- Seamless integration and coordination in the entire framework that includes both the control structures and the controllers by mimicking the central nervous system

Our Approach

Features of the Proposed Approach
- Self-organization of the control structure that mimics the function of the cortical areas of human brain - dynamic switching between SISO, SIMO, MISO, and MIMO configurations
- Distributed and adaptive controllers that mimic the rule of pursuit present in ants
- Intelligent monitoring, cognition, and decision capabilities that mimic the immune system
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Biomimetic Controller Design
- Algorithm inspired by rule of pursuit for ants
  - First agent follows an assumed random trajectory
  - Subsequent agents follow the trajectory of their leader with some modification
  - Cooperative work in large number of agents results in optimal control trajectory
  - Intermediate optimal control problems solved employing MATLAB toolboxes (e.g., dynopt)
  - Adaptive laws and stochastic control concepts explored to address randomness and presence of disturbances

Intelligent Monitoring, Cognition, and Decision Capabilities
- Inspired by the functionality of the immune system with emphasis on the synergistic interaction between its main components: innate and adaptive.
- Globally addresses the issue of abnormal condition detection, identification, evaluation, and accommodation (ACDIEA)
- Biomimetic monitoring and control (BMC) based on the artificial immune system (AIS) paradigm

Multi-Agent Optimization Framework
- The multi-agent optimization framework
  - uses different algorithms as agents for optimization
  - uses biomimetic optimization techniques such as genetic algorithms, simulated annealing, ant colony based optimization
  - Each agent is autonomous
  - Overall control and schedule to use various algorithms
  - High probability of finding global optimum

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