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

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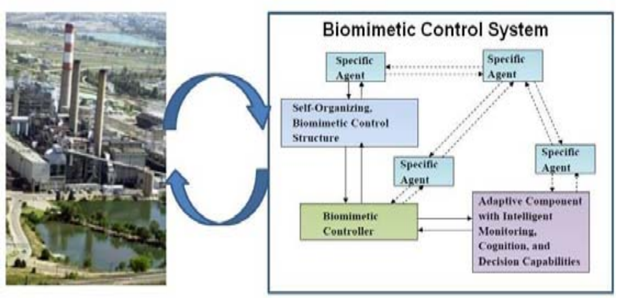
Challenges in Modern Control

- 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

Our Approach

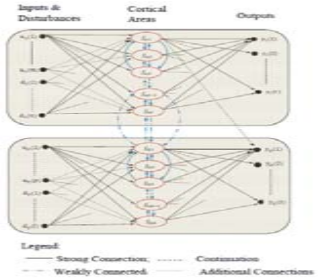


Features of the Proposed Approach

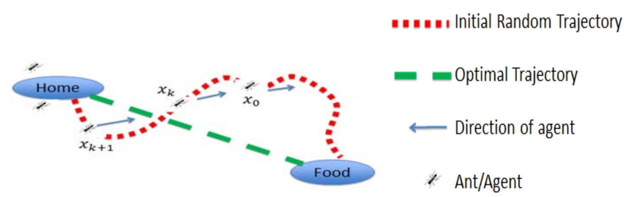
- Self-organization of the control structure that mimics the function of the cortical areas of human brain- dynamic switching between SISO, SIMO, MISO, and MIMO configurations
- Distributed and adaptive controllers that mimic the rule of pursuit present in ants
- Intelligent monitoring, cognition, and decision capabilities that mimic the immune system
- Seamless integration and coordination in the entire framework that includes both the control structures and the controllers by mimicking the central nervous system

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



Biomimetic Controller Design

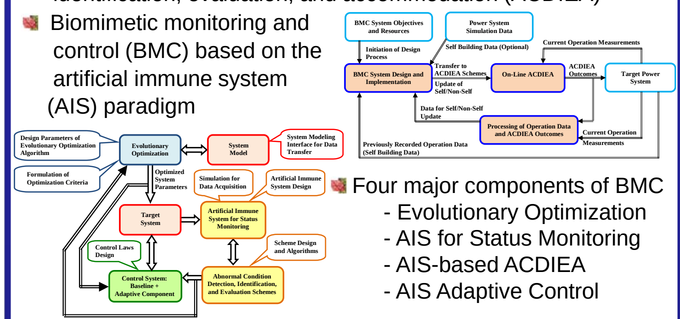


Algorithm inspired by rule of pursuit for ants

- 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

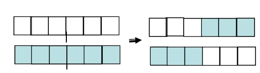
- Inspired by the functionality of the immune system with emphasis on the synergistic interaction between its main components: innate and adaptive.
- Globally addresses the issue of abnormal condition detection, identification, evaluation, and accommodation (ACDIEA)
- Biomimetic monitoring and control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

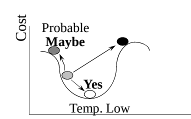


- Four major components of BMC
  - Evolutionary Optimization
  - AIS for Status Monitoring
  - AIS-based ACDIEA
  - AIS Adaptive Control

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





Acknowledgement

Funding by US DOE- National Energy Technology Laboratory through grant # DE-FE0012451