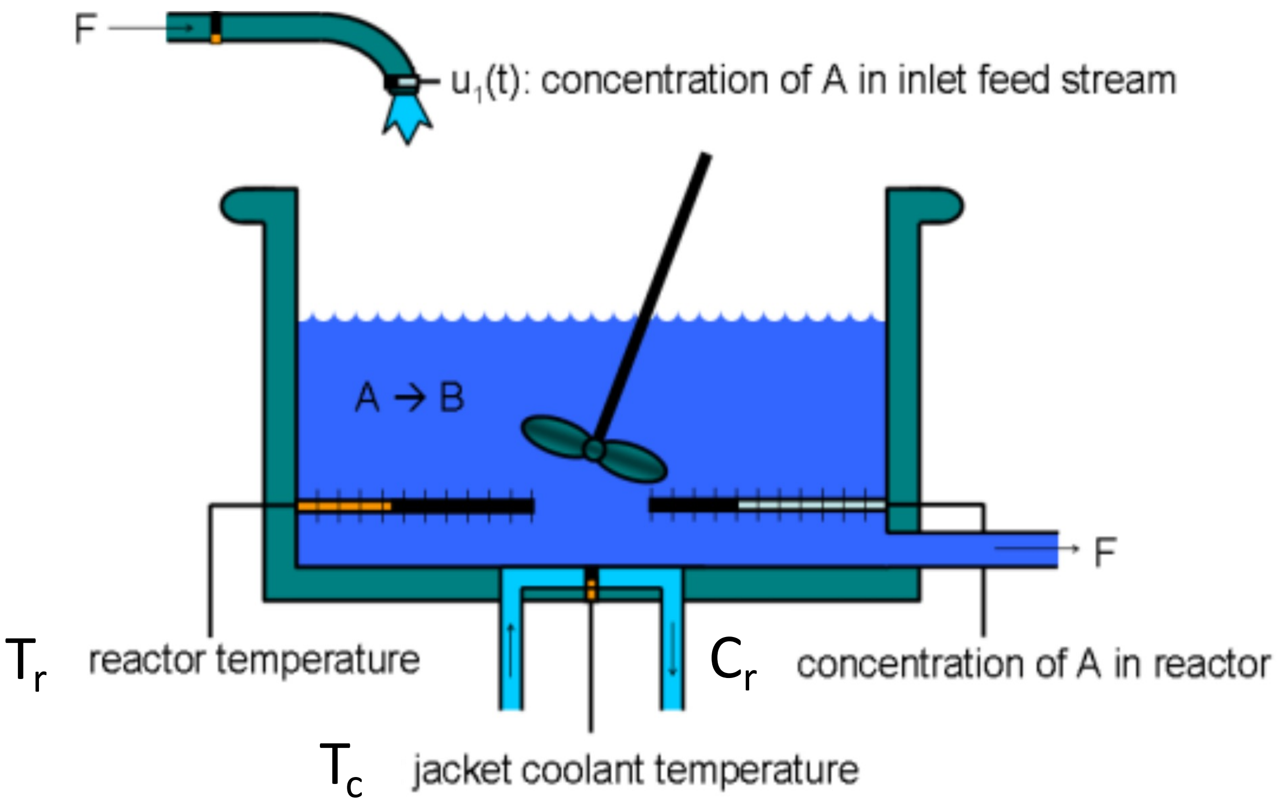
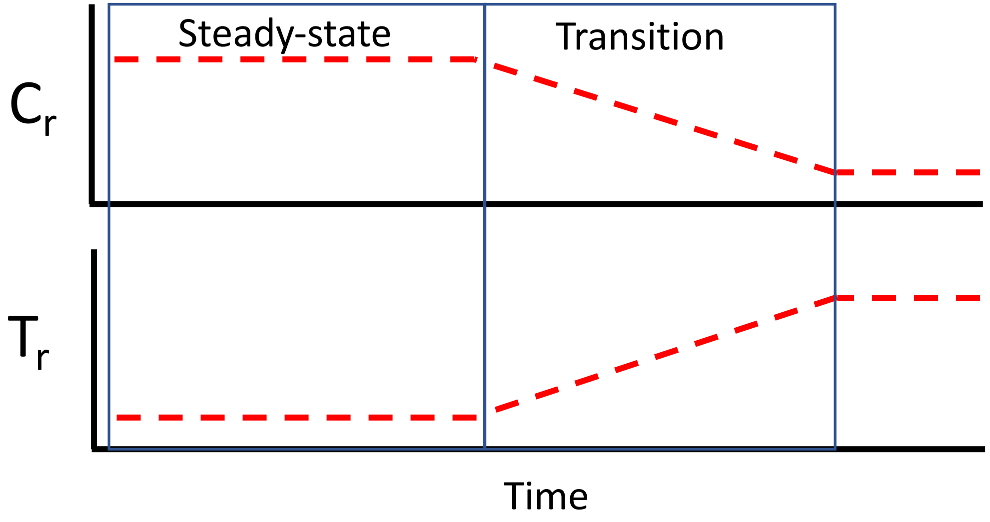
Chemical Reactor Optimization

Chemical Reactor Optimization

Overview

- Continuously stirred tank reactor (CSTR)
- Exothermic reaction must be controlled to prevent thermal runaway (> 400 degrees K)
- Continuous production of a single product, it is a steady-state process
- Transitioning the reactor to producing another product requires close monitoring





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Current Methods

- Advanced control methods
- Adaptive Proportional, Integral Derivative Control (PID)
- Model Predictive Controller (MPC)

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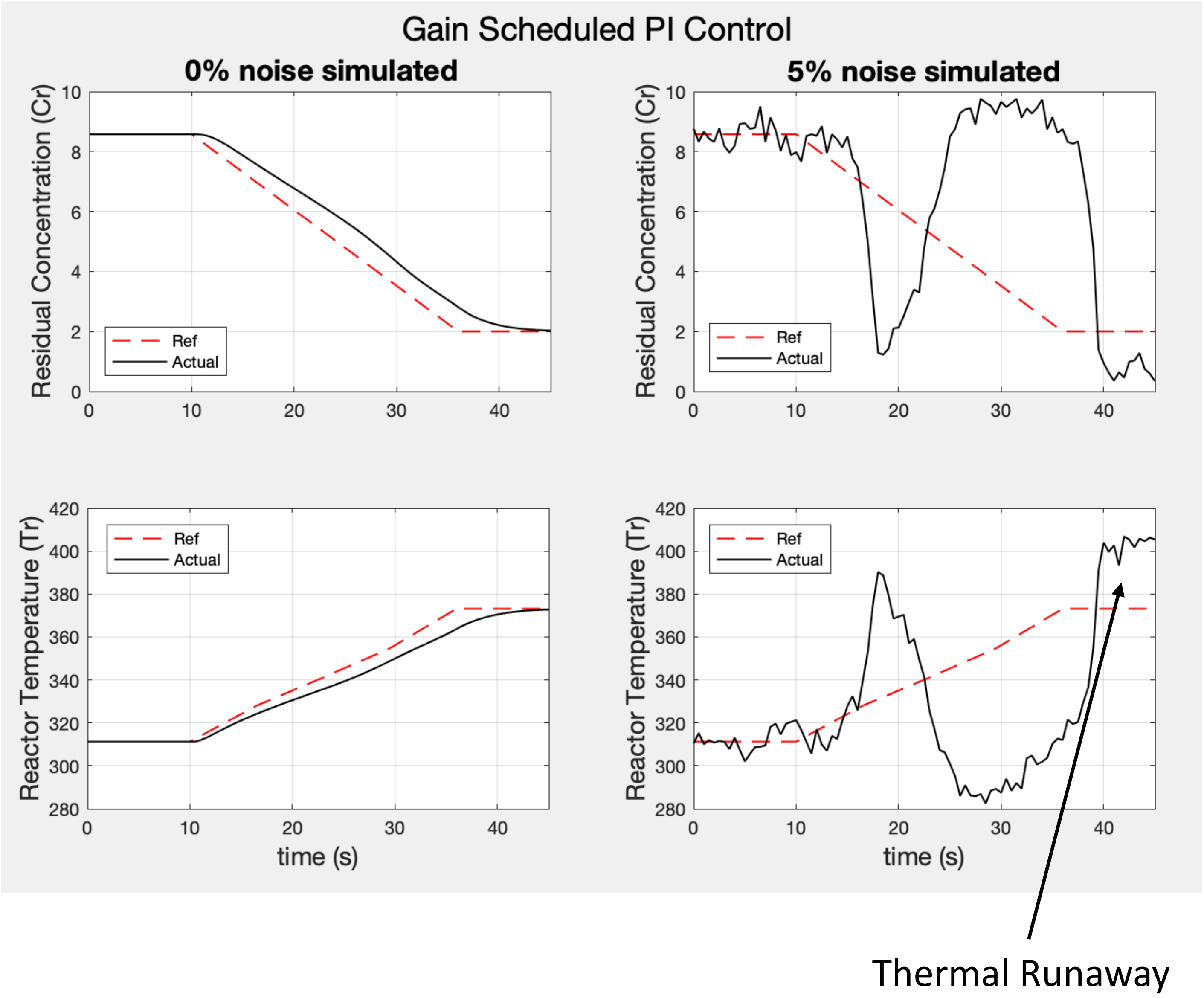
Limitations of current methods

- Adaptive PID does not respond well to noise or variability
- MPC is extremely time consuming to develop and drifts over time
- Can take months for experienced engineers to develop new product transition controllers



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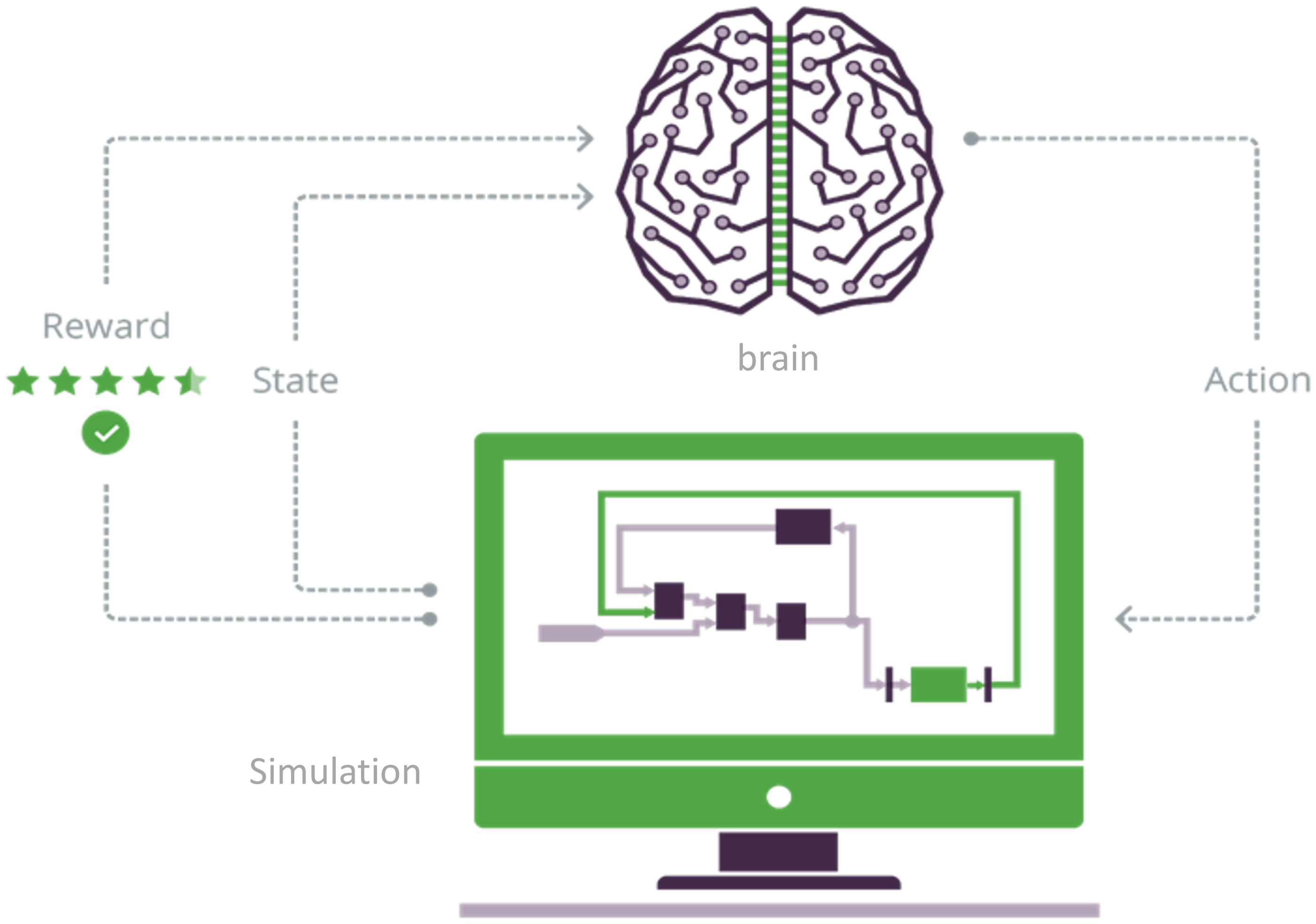
Solution: Autonomous AI

- Develop an Autonomous AI Brain using Deep Reinforcement Learning
- Brain learns to adapt by training in simulation
- AI can generalize across scenarios
- Can handle uncertainty, like noise
- Brain training can be scaled on the cloud to accelerate AI development



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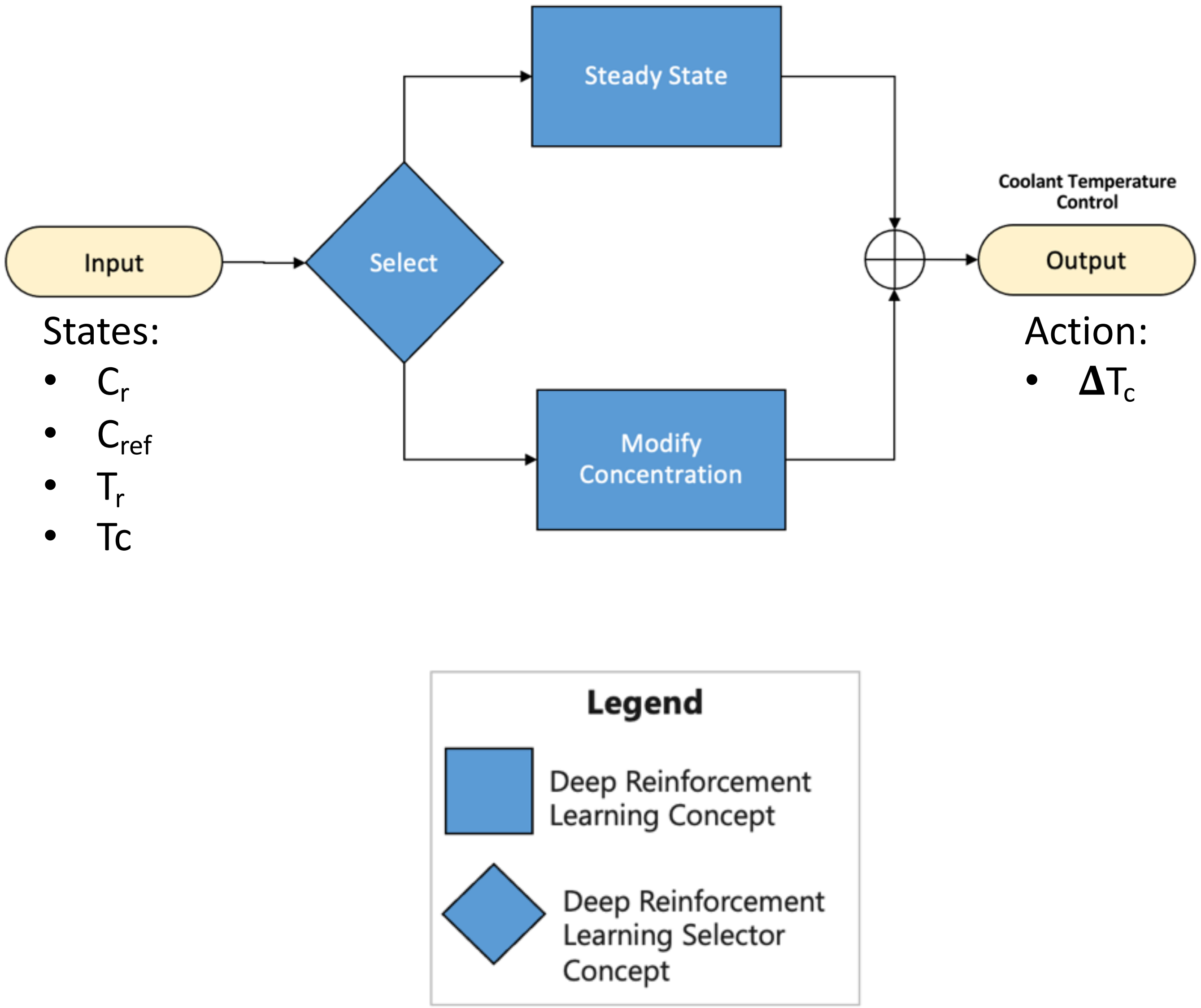
Brain Design

- Steady State Concept operates the reactor coolant temperature when there is a constant reference concentration
- Modify Concentration Concept operates the reactor coolant temperature during a product transition
- Selector Concept chooses the appropriate concept based on observing the reactor conditions



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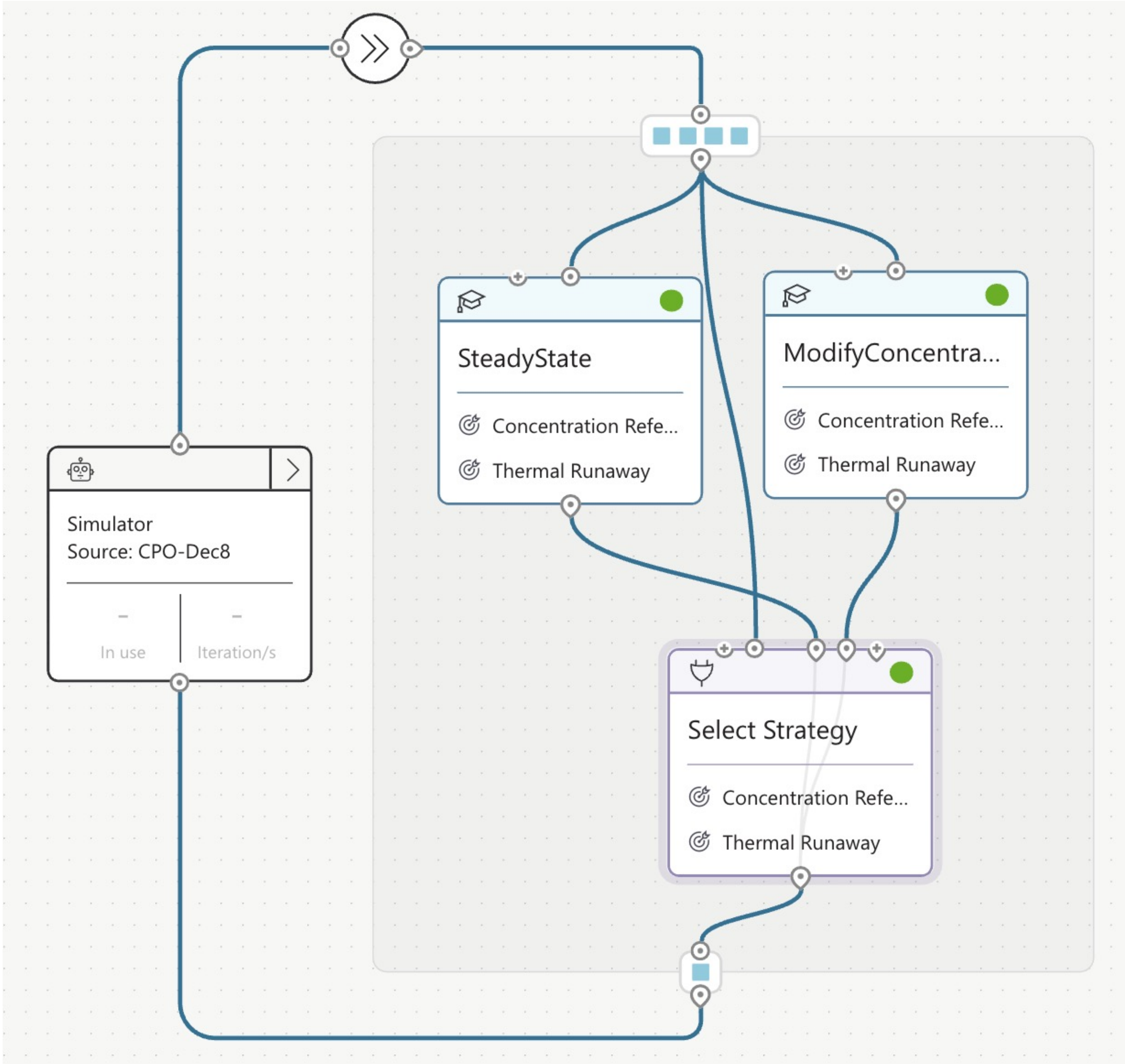
Brain Development

- Objectives:
  - Prevent thermal runaway while transitioning the residual concentration of a CSTR
  - →Minimize Error to reference concentration
  - →Avoid Thermal Runaway (>400 K)
- Training:
  - Vary Sensor Noise 0-5% noise



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Results

- Brain outperforms Benchmark Gain Scheduled PI Controller with more margin the more realistic the simulation (more noise)
- Benchmark results in thermal runaway for 5% noise
- Brain avoids thermal runaway for up to 10% noise