INL/MIS-23-72152-Revision-0

Can We Use Machine Learning to Control Nuclear Power Plants?

April 2023

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Changing the World's Energy Future

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Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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Acknowledgements

Idaho National Laboratory

Ahmad Al Rashdan

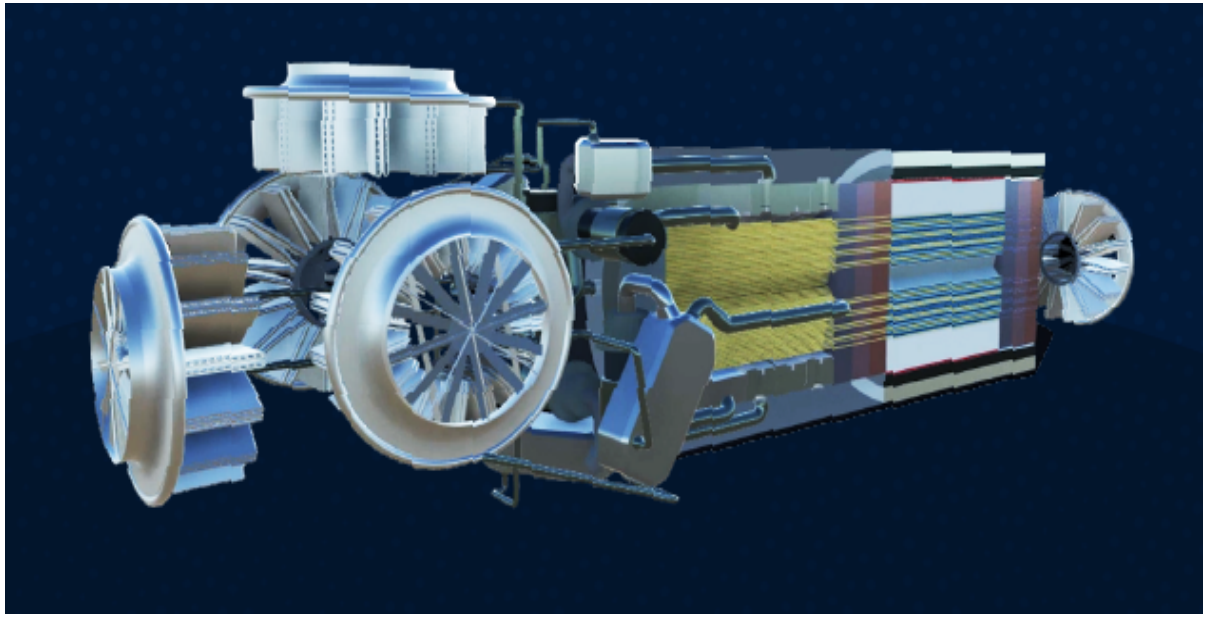
Craig Primer

Maria Coelho

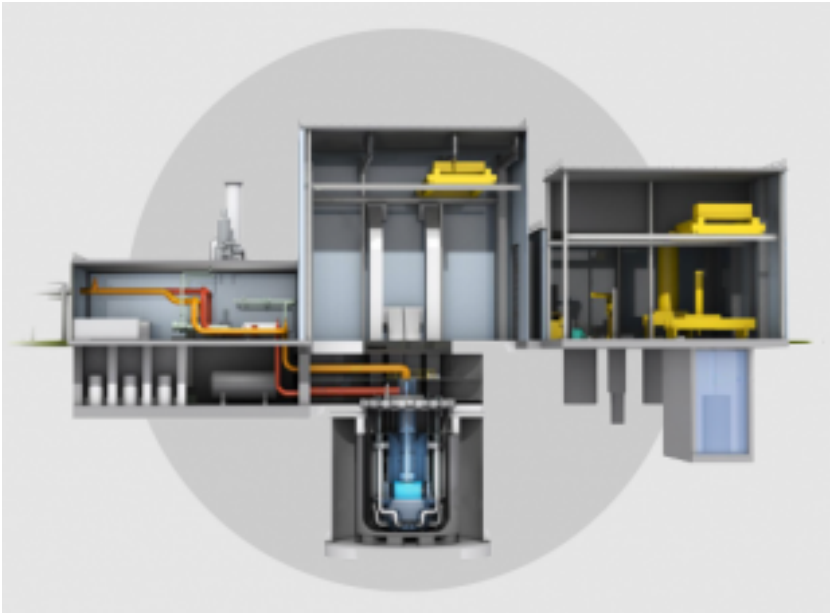
Vaibhav Yadav

ASI Advanced Sensors and Instrumentation

Advanced reactors will be highly autonomous and remotely controlled, and will operate at variable power ratings and in rural locations



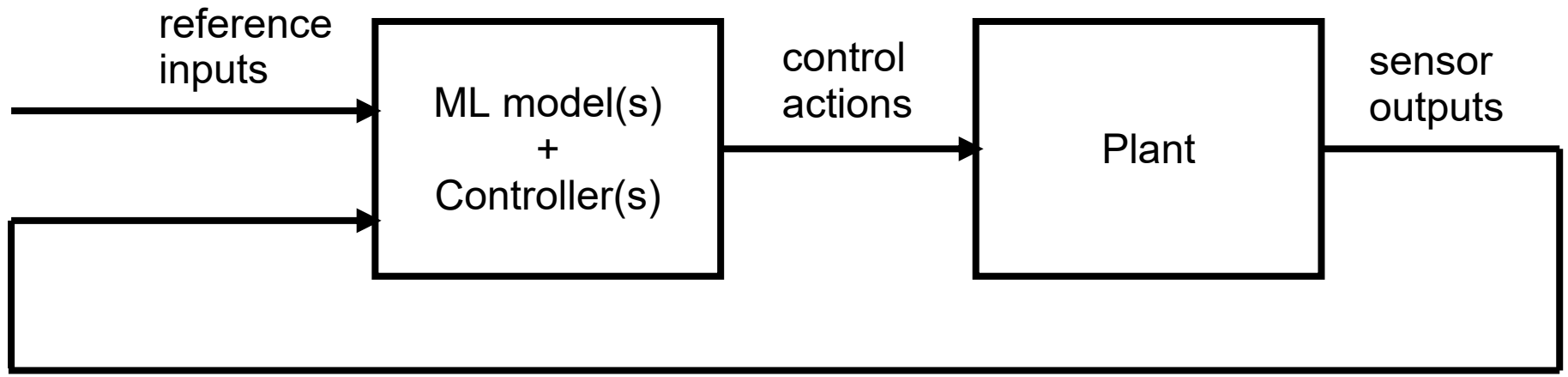
https://www.energy.gov/ne/articles/what-nuclear-microreactor

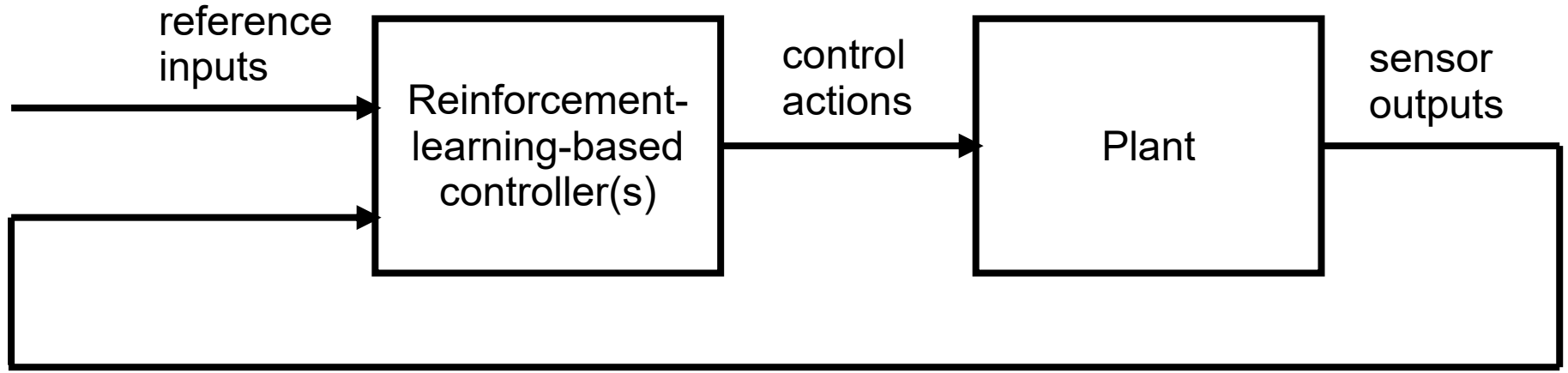


https://www.energy.gov/ne/articles/infographic-advanced-reactor-development

These characteristics necessitate more intelligent means of control

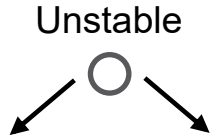
Typical methods of ML-based intelligent control either use ML to model the plant or use reinforcement learning to directly learn control



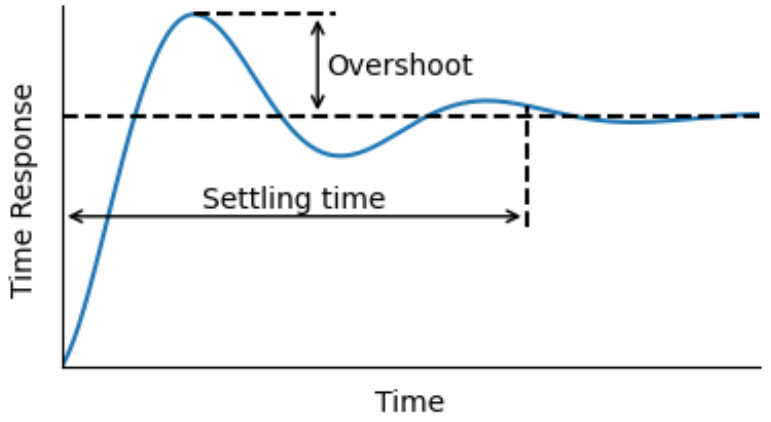


Regulatory requirements consider the determinism, simplicity, explainability, and verifiability of NPP control systems

- Example general considerations
  - Many ML algorithms are stochastic
  - Many ML algorithms are black box in nature
- Example control-specific consideration
  - ML-based control lacks history of verifiable stability and performance

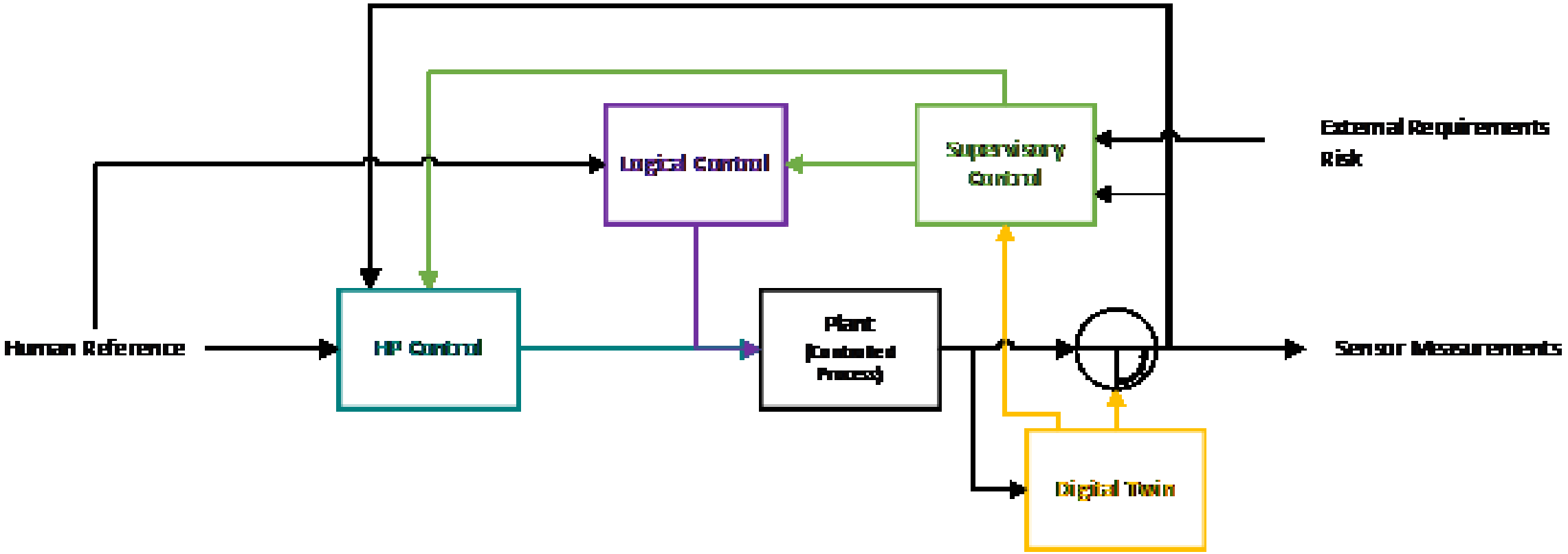


Stable

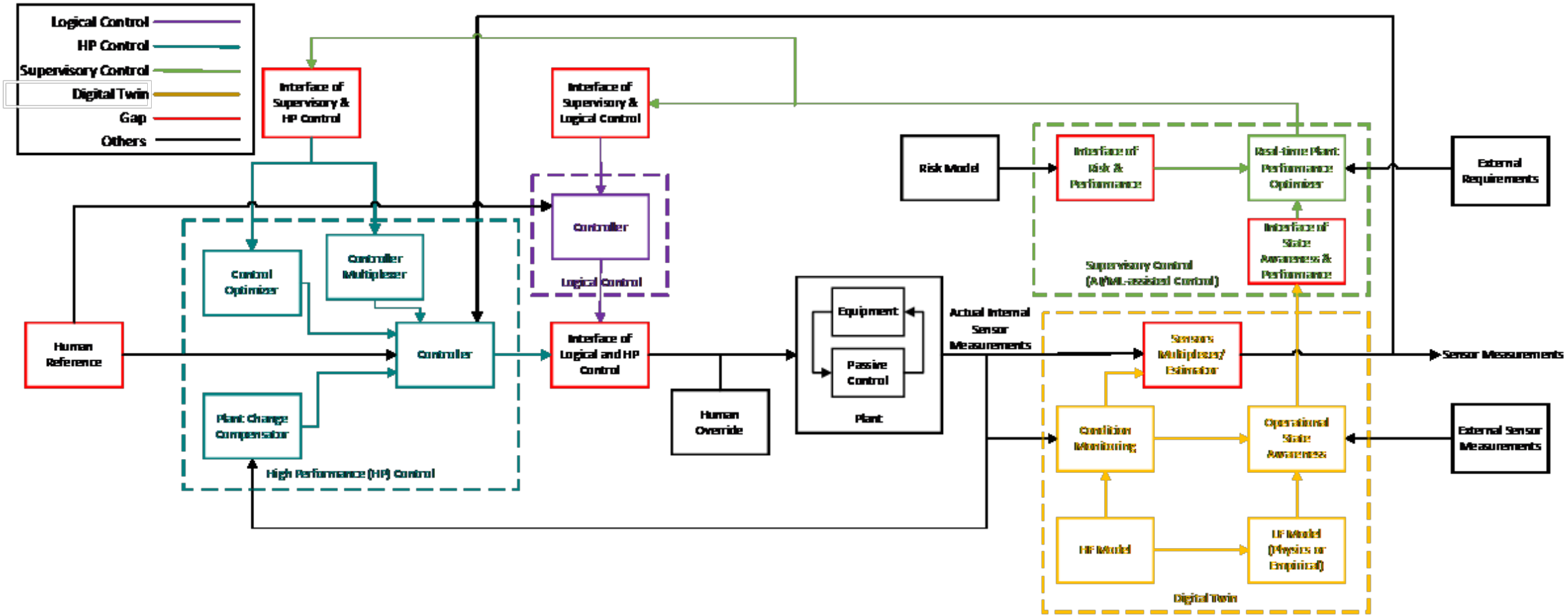


New solutions may be necessary to overcome these barriers in using ML to directly control NPPs

Alternatively, high-performance control could be employed for direct control, with ML implemented via supervisory control and digital twins



These systems can be expanded to show research gaps that need to be closed before implementing this hierarchical approach



Conclusions

- Using ML to directly control NPPs may necessitate new solutions that consider determinism, simplicity, explainability, and verifiability
- Our hierarchical solution can be broken into two parts:
  - Perform direct control using high-performance methods that possess these important characteristics
  - Provide control support and analysis by using digital-twin-assisted supervisory control that can benefit from ML and conveys less risk
- Many open research questions remain to be answered before this hierarchical solution can be implemented

Questions?
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