

Challenges in Satisfying the Need and Promotion of Modeling & Simulation Workforce

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About me

- Industry practitioner
 - Embedded controls and industrial automation for diesel engine manufacturing and applications at Cummins
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- Data-driven + model-based approach at Bosch
- Model-based design problems from Toyota during PhD
- Academic researcher
 - Control, robotics, AI/ML, formal analysis, more during MS at Penn
 - Multi-formalism Model-Based Design, formal analysis during PhD at Carnegie Mellon
 - Software and system architecture during PhD at Carnegie Mellon

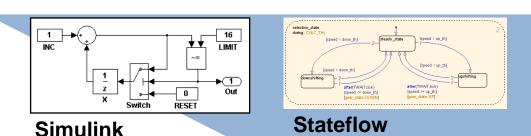


- Research Scientist
 - Work on building a modeling and simulation platform
 - Used by industry practitioners and academic researchers alike





[Modeling]: Model-Based Design and Systems Engineering







MATLAB

C, C++ S-functions



Graph level & algorithm level analysis

Modeling semantics level analysis

Implementation level analysis

C code

C++ code

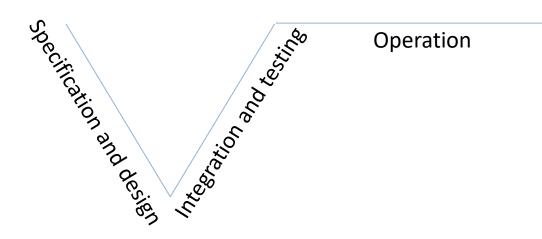
HDL code

PLC code

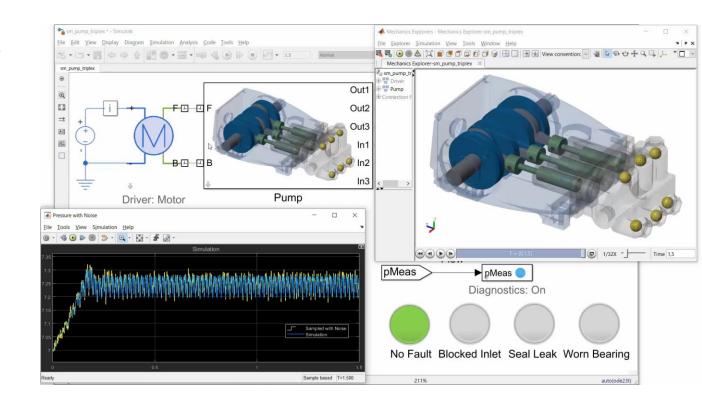
GPU code



[Modeling]: Model-Based Operation with Digital Twins



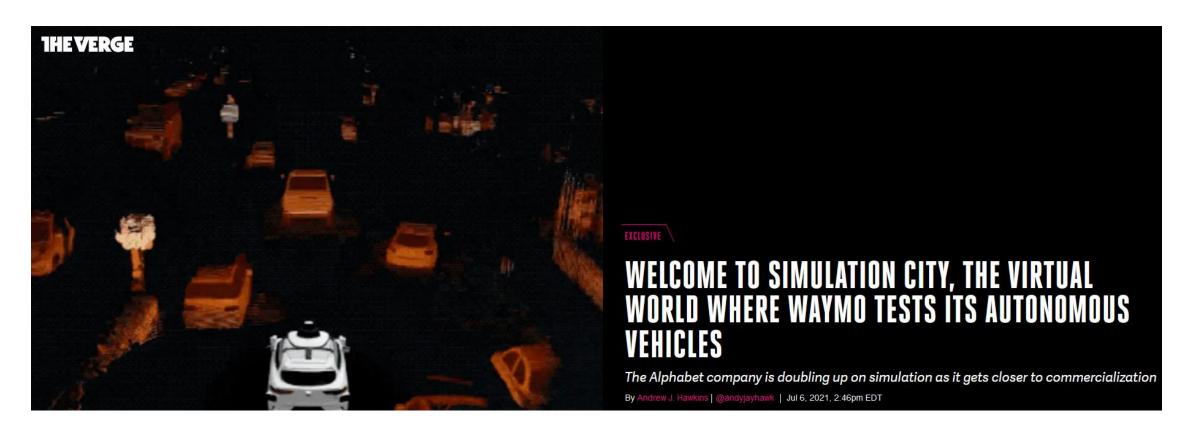
Challenges in the Operation and Design of Intelligent Cyber-Physical Systems, S. Castro, P.J. Mosterman, A.H. Rajhans, and R.G. Valenti, book chapter, Complexity Challenges in Cyber Physical Systems: Using Modeling and Simulation (M&S) to Support Intelligence, Adaptation and Autonomy, S. Mittal and A. Tolk, eds., Wiley, 2019.



https://www.mathworks.com/discovery/digital-twin.html



[Simulation] Increasing relevance (example): Billions of 'Simulation miles' driven by autonomous vehicles



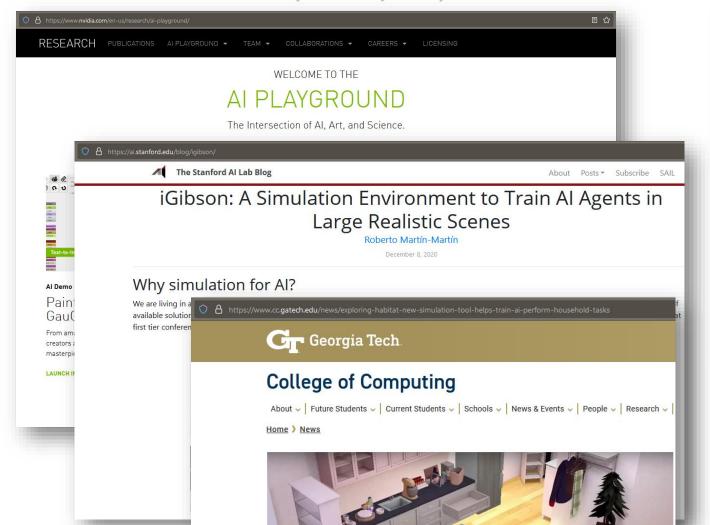
https://www.theverge.com/2021/7/6/22565448/waymo-simulation-city-autonomous-vehicle-testing-virtual

https://techcrunch.com/2019/07/10/waymo-has-now-driven-10-billion-autonomous-miles-in-simulation/

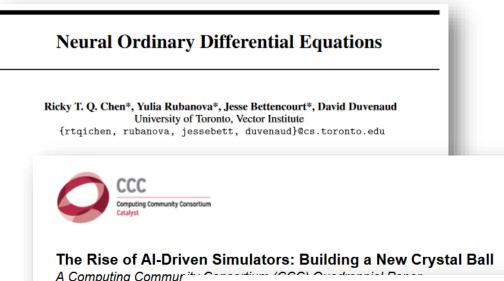


New paradigms with the advent of Al

Simulation for AI (examples)



Al for Simulation (examples)



A Computing Commur " > Defense Advanced Research Projects Agency > Our Research > Symbiotic Design for Cybe

Ian Foster (University of C AI Research)

Fifty years ago, weather fo would be the same as toda future, allowing individuals Dr. Sandeep Neema transformation is due in la simulation, a method for u

First developed in the last throughout human society not just for next week's we weather patterns, the effe material in future batteries

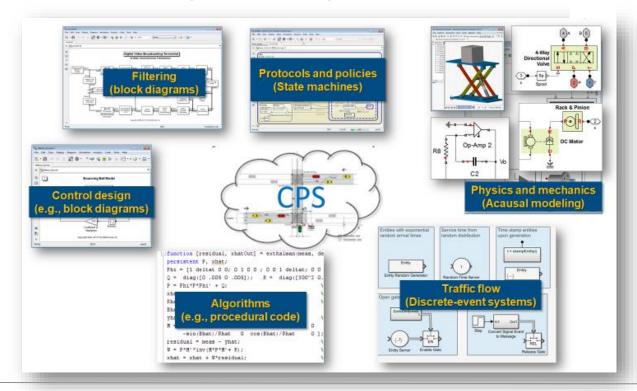
Symbiotic Design for Cyber **Physical Systems**

Cyber physical systems (CPS) are instrumental to current and future Department of (DoD) mission needs - unmanned vehicles, weapon systems, and mission platforms examples of military-relevant CPS. These systems and platforms integrate cyber and subsystems, and the enormous complexity of the resulting CPS has made their engi a daunting challenge. An immediate consequence of this complexity is development prolonged timelines that challenge DoD's ability to counter emerging threats

CPS design is a complex endeavor that involves many domains – from cyber (e.g., s control computing and communication) to physical (e.g., structural mechanical

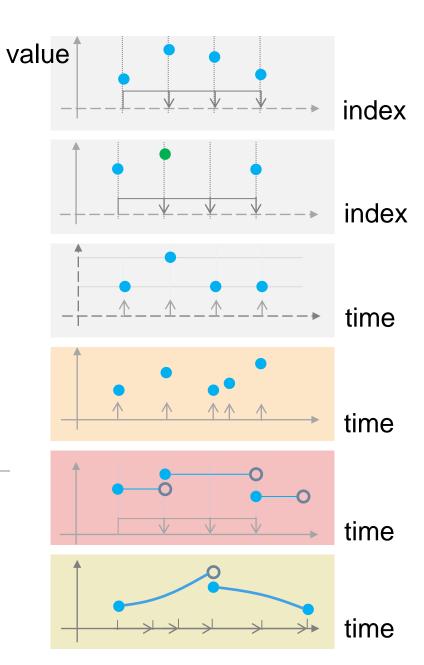


Research challenges (example): addressing heterogeneity



Multi-Model Heterogeneous Verification of Cyber-Physical Systems, A. Rajhans, PhD Thesis.

Simulation of Hybrid Dynamic Systems, P.J. Mosterman, *A. Rajhans*, A. Mavrommati, R.G. Valenti, Springer Encyclopedia of Systems and Control, Second Edition





Summary

- Modeling and simulation continues to play a pivotal role, from design time to operation time
- Deployment landscape increasingly complex with IoT scenarios
- New world of opportunities with the advent of AI
- Fundamental questions about multi-formalism multi-scale analysis still relevant
- Need for curricula and continued education in Modeling and Simulation