USING A DIGITAL TWIN OF THE OSU TRIGA REACTOR TO MAKE A HYBRID SIMULATION

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ABSTRACT

By creating a hybrid simulation of the OSTR facility through multiple digital twins, we can investigate the usefulness and application of hybrid simulations in the wider nuclear industry. This is important as creating models of nuclear systems can be costly, time consuming and often comes with safety risks. Using a hybrid simulation would allow for a portion of the model in question to be digital, which saves on space and costs, while maintaining a physical component with which to compare.

WHAT IS A HYBRID SIMULATION?

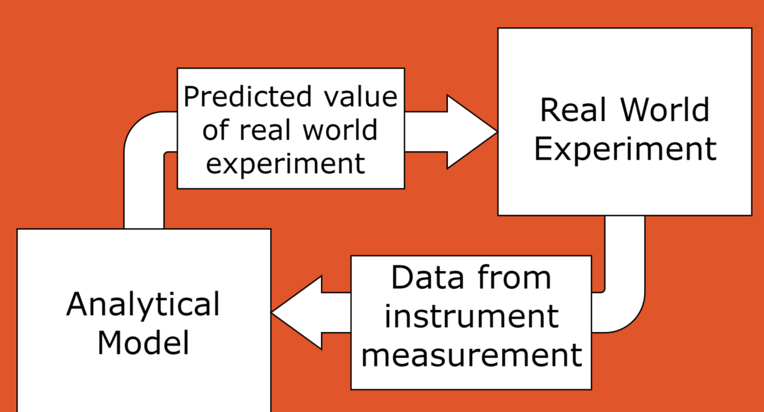

Figure 1: Hybrid Simulation System

Hybrid simulations combine different modeling approaches, such as deterministic methods and continuous event simulations, making it an accurate and versatile simulation technique for exploring the complex phenomena within reactor systems. In addition, hybrid simulations allow researchers to better optimize computational resources by employing simplified models where appropriate and reducing the need for physical space. This can significantly cut set up costs and simulation run time for high fidelity models that typically require many resources, such as detailed computational fluid dynamics simulations.

METHOD

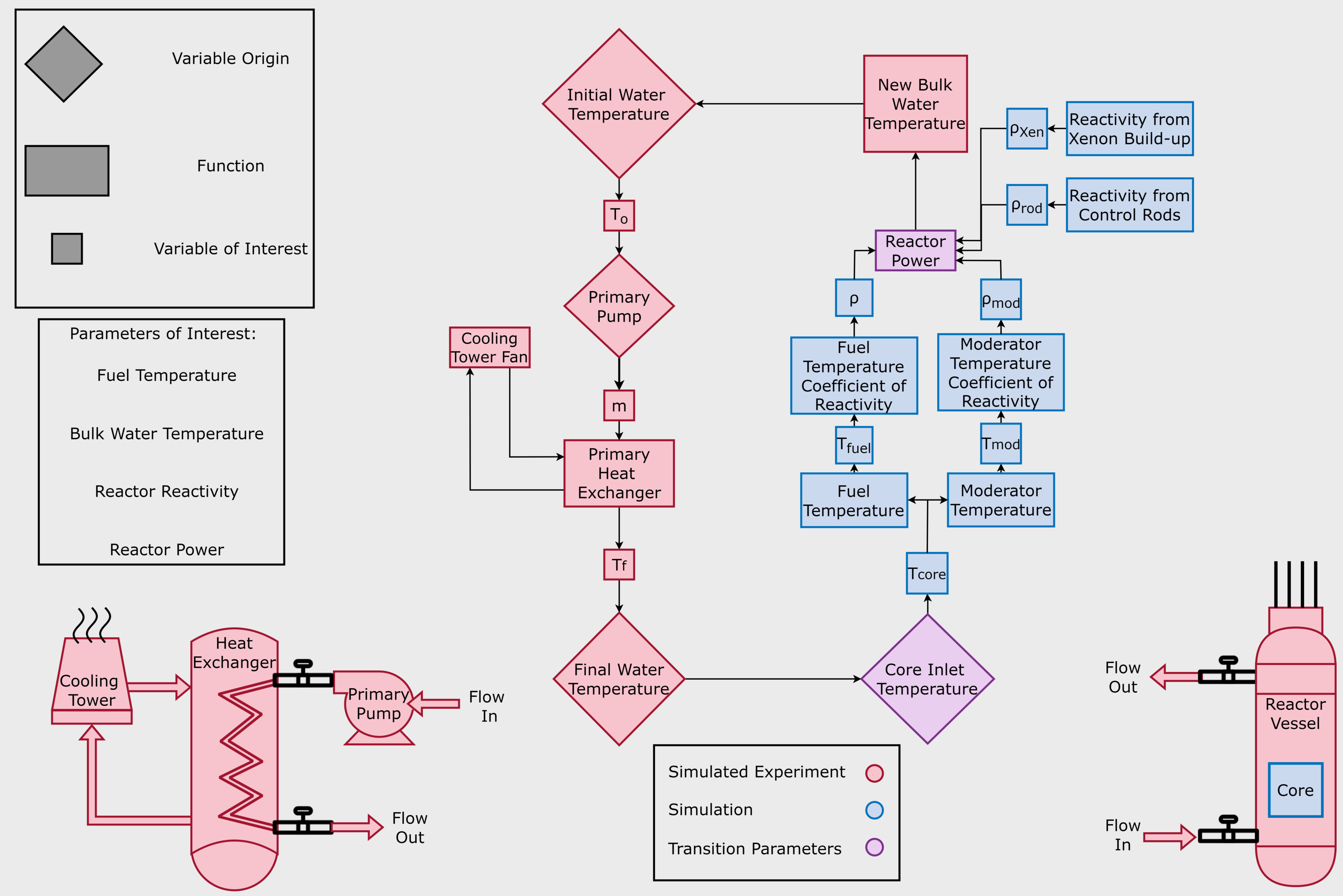

Figure 2: Code Flow Chart

METHODOLOGY

To accurately describe the OSTR it is necessary to consider multiple physics phenomena. For a nuclear reactor, this can be broadly broken down into two sections: neutronics and thermal hydraulics. Neutronics considers the physics within the core and helps describe the power and flux of the core. The thermal hydraulics considers the cooling system and the mass flow throughout the reactor. Coupling these two physics phenomena together creates a more accurate model and is the basis for our construction of the digital twin of the OSTR.

IMPLEMENTATION

First, to accurately describe the behavior of the core we employed the use of the point reactor kinetics equations (PRKE). This set of coupled differential equations describes the power and neutron precursor concentrations over time. A forward Euler scheme was implemented to integrate the PRKE. While Cylindrical heat conduction is used to calculate the fuel temperatures. Newtons law of cooling was used to create an adaptive heat exchanger that adjusts heat transfer coefficient for increased primary temperatures. Together these codes create an effective digital twin of the OSTR facility.

RESULTS & DISCUSSION

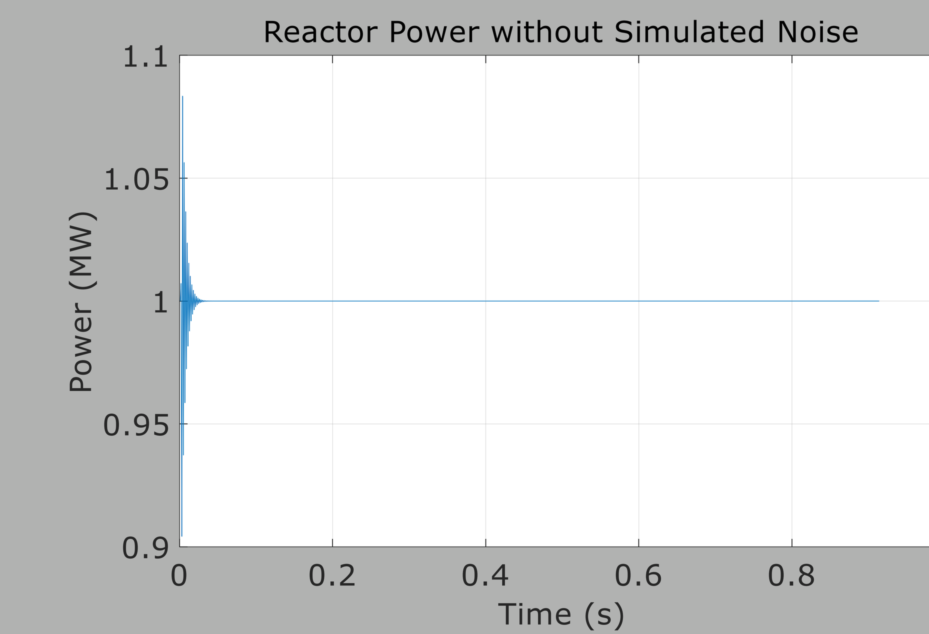

Figure 3: Reactor Power in Digital Twin

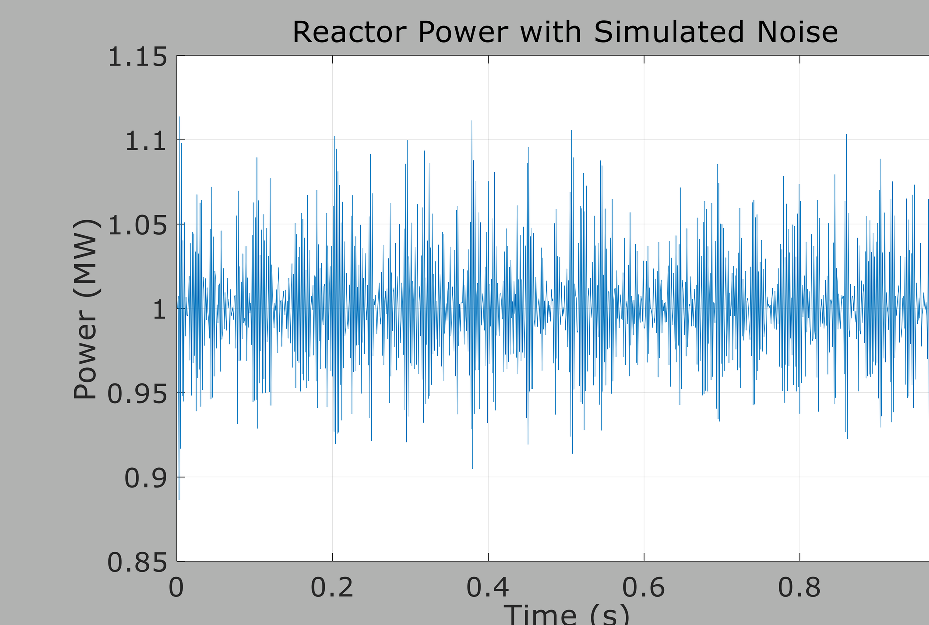

Figure 4: Reactor Power in Digital Twin with Simulated Noise

CONCLUSIONS & FURTHER RESEARCH

By adding noise to the temperature value, a rough estimation of a hybrid simulation output is obtained. This allows someone to explore the possibilities of a hybrid simulation in a completely digital space.

The validity of the hybrid simulation will be as good as the accuracy of the digital twin. Creating an accurate and as close to 1:1 model of the system is extremely important when implementing hybrid simulations while also making necessary sacrifices for computational speed. Future research into digital modeling, advanced computer codes, and cross-physics data transfer are all recommended research topics that should produce a better model than we have created here.

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