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Management of time in data-driven computational steering

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1. Introduction

The Computational Steering, which emerged around the 1970s, is an interactive way to utilize high performance computing resources and to understand the working process of simulations. Around 2004, data-driven approaches simulated interest in combining processing of data via machine learning with computation based on modelling of the physical processes, leading to the development of interest in ways of using data to steering computations, this is called data-driven steering.

Such conceptualisations of the steering of computation introduce considerations of the interaction between the physical and digital worlds. Especially, models of time can be different in the physical world (mathematically continuous time) and in the digital world where computations model the state of such systems (mathematically discrete time). We describe time issues in data-driven steering in which the data is collected from the interaction of digital components, e.g. sensors, with the physical world and this data is also used to control digital processes.

2. Work Flow of Computational Steering

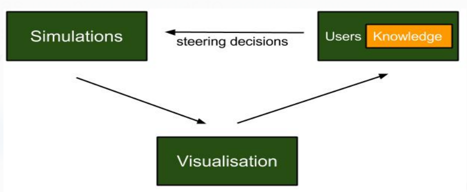

Figure 1 – Current Work-flow of Computational Steering

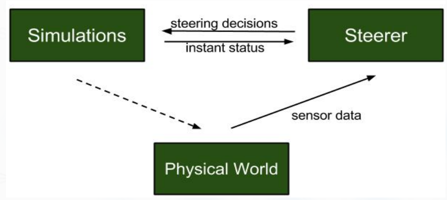

Figure 2 – The Work-flow of Data Driven Computational steering

3. Time in Steering

- Time and non-time related simulations
- Single time step, continuous execution and steering
- Difference between parameters and state space variables

4. Network Simulation

This work analyses a water distribution system as a representative of cyber-physical system and select a typical pre-developed simulation to conduct the analysis. The simulation is based on four fundamental function: 1) data exchange, 2) simulation, 3) calibration and 4) prediction.

5. Time Issues in Current Scheme

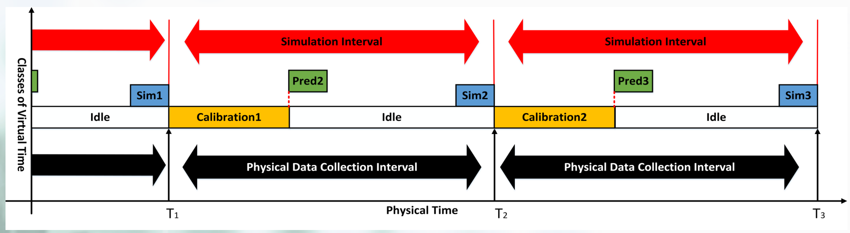

Figure 3 – Ideal situation for network simulation

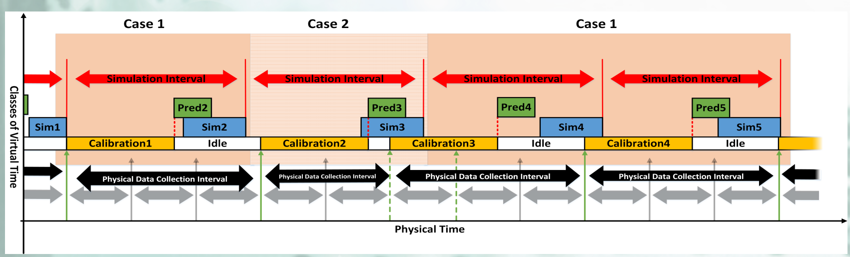

Figure 4 – Example scenario based on times measured in a water network simulation

6. Conclusion

The theory of time management in computational steering represents an interesting way to tackle uncertainties in the interaction between the computational and physical representations of a system. In order to integrate this theory into simulation and control of the physical world, this work introduces a framework named Data-Driven Computational Steering in which human users are replaced by artificial intelligent algorithms and a time management component. By analysing the interdependence of the time intervals required to complete the objective functions and and simulation time advances, we emphasise the importance of time management and coordination in the systems that link the computational simulation with the physical system it is attempting to track and predict. Moreover, due to the dynamism of the physical world, this work explores physical uncertainties in the WDS that impede coordination among functional components on the computational side.

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