Dynamic Data Driven Applications Systems – DDDAS 2008

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Abstract. This workshop is centered about the recently emerged paradigm of Dynamic Data Driven Applications Systems (DDDAS). The DDDAS concept has already been established as a revolutionary new approach of a symbiotic relation between application and measurement systems, where applications can accept and respond dynamically to new data injected into the executing application, and reversely, the ability of such application systems to dynamically control the measurement processes. The synergistic feedback control-loop between application simulations and measurements can open new domains in the capabilities of simulations with high potential pay-off: create applications with new and enhanced analysis and prediction capabilities and enable a new methodology for more efficient and effective measurement processes. This new paradigm has the potential to transform the way science and engineering are done, with major impact in the way many functions in our society are conducted, such as manufacturing, commerce, transportation, hazard prediction/management, and medicine. The workshop will present such new opportunities, as well as the challenges and approaches in the applications', algorithms' and systems' software technologies needed to enable such capabilities, and will showcase ongoing research in these aspects with examples from several important application areas.

1 Overview

More and more applications are migrating to a data-driven paradigm including contaminant tracking, chemical process plants, petroleum refineries, well bores, and nuclear power plants. In each case sensors produce large quantities of telemetry that are fed into simulations that model key quantities of interest. As data are processed, computational models are adjusted to best agree with known measurements. If properly done, this increases the predictive capability of the simulation system. This allows what-if scenarios to be modeled, disasters to be predicted and avoided with human initiated or automatic responses, and the operation of the plants to be optimized. As this area of computational science grows, a broad spectrum of application areas will reap benefits. Examples include enhanced oil recovery, optimized placement of desalination plants and other water intakes, optimized food production, monitoring the integrity of

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engineered structures and thus avoiding failures, and real time traffic advice for drivers. These are but a few of countless examples.

Visualization is used at all stages of DDDAS: setting up data and initial and/or boundary conditions, seeing and analyzing results, and steering computations.

DDDAS is ripe for multidisciplinary research to build applications, algorithms, measurement processes, and software components from which tools can be developed to solve diverse problems of regional and international interest. The advances that will result, including enhanced repositories of re-usable software components and high quality real time applications, support of separation of concerns, and reduced development time, will be of great value to industry and governments, and will set the stage for further valuable research and development and new education paradigms for students. A comprehensive list of ongoing state of the art projects is kept up to date on http://www.dddas.org in the projects area.

Several research thrusts in which advances should significantly enhance the abil ity of data-driven computational science to bring its tremendous benefits to a w ide array of applications. These research thrusts are,

- Effective *assimilation* of streams of data into ongoing simulations.
- *Interpretation, analysis, and adaptation* to assist the analyst and to ensure the most accurate simulation.
- *Cyberinfrastructure* to support data-driven simulations.

These three areas interact with two other research fields symbiotically: (1) forward multiscale modeling and simulation, and (2) deterministic and statistical methods in inverse problems.

Research areas (1) and (2) combined with (3) DDDAS must work within the context of uncertainty and will benefit from the development of statistically sound, unified treatments of uncertainties. For example, in forward multiscale modeling and simulation, input data are uncertain and these uncertainties should be propagated to uncertainties in output quantities of interest. In an inverse problem, proper treatment of measurement uncertainties and errors must be integrated with treatment of uncertainties associated with bforwardb models. be treated systematically. In a data-driven application, all of these uncertainties are present and must

Data management in a DDDASis typically supported by tools for data acquisition, data access, and data dissemination. Data acquisition tools retrieve the real time or near real time data, processing and storing them. Data access tools provide common data manipulation support, e.g., querying, storing, and searching, to upper level models. Data dissemination tools read data from the data store, format them based on requests from data consumers, and deliver formatted data to data consumers.

DDDAS is *the* paradigm of the data rich information age that we live in.