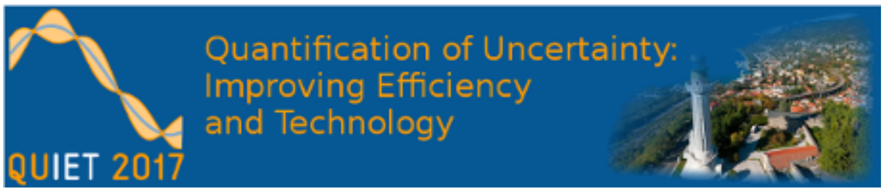

Model order reduction for real time decisions from incomplete and uncertain measurements

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Next generation of autonomous vehicles will be able to make operational decisions in real-time to face and cope with unplanned circumstances without compromising the successful completion of their tasks. Accounting for unplanned circumstances requires the ability to monitor and capture both the evolution of the system health (self-awareness) and the dynamic change of the surrounding environment (situational awareness). This form of autonomous reasoning can be formalized as instance of the general paradigm of a Sense-Infer-Plan-Act flow able to process data into information, information into knowledge, and knowledge into intelligent decisions. In the Sense-Infer-Plan-Act framework, awareness encompasses the ability to (i) sense informative quantities, (ii) use measured data to infer the state of the system, and (iii) use this estimate to update system capabilities and re-plan operational strategies. Our studies [1, 2, 3, 4] address the specific problem of supporting self-awareness and propose to associate the Sense-Infer-Plan-Act flow with measurements (physical quantities that can be monitored with sensors) and capabilities (quantities that evolve with the state of the system and limit the operational space). In this framework, we tackle the time-constrained problem of obtaining efficient estimates of capabilities from sensor measurements; in particular, we consider measured data that may be incomplete and affected by uncertainties in both sensor location and sensor accuracy. To achieve this goal, we develop an offline-online methodology that combines model order reduction and localization techniques into a Multi-Step Reduced Order Modeling (MultiStep-ROM) procedure. In addition, we propose a novel approach for the identification of the most informative sensor locations: this strategy couples unsupervised learning techniques with MultiStep-ROM and allows for a drastic reduction in the number of sensors required to achieve reliable predictions of capabilities and well-informed decisions. We apply our methodologies to the practical case of autonomous aerospace vehicles that dynamically adapt their mission to the evolution of their structural state. In particular, our approaches are demonstrated for the real-time structural assessment of a composite wing panel undergoing a variety of damage conditions.

References

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