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A real-time variational data assimilation method with hybrid modelling: Application to additive manufacturing

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The online monitoring of the additive manufacturing process is a difficult task as the associated physical phenomena are multiphysics and multiscale. The main difficulty comes from the numerical complexity which is associated to an expensive computation hardly compatible with real-time. To overcome this issue, the high-fidelity parameterized physical model may be simplified, however as a model bias is added, the numerical estimations need to be corrected with assimilation techniques on observation data. The present study is mainly dedicated to perform state estimation using an extension, for time-dependent problems, of the Parameterized Background Data-Weak (PBDW) method introduced in [1, 2]. This method is a non-intrusive, reduced basis and in-situ data assimilation framework for physical systems modelled by parametrized PDE; it was initially designed for steady-state problems. In the context of additive manufacturing, the approximation to the true temperature field of the studied layer given by a thermal camera has two contributions: an estimation by a reduced order model enhanced on-the-fly, and an update informed by the observations (correction of model bias). Furthermore, to forecast future states a prediction needs to be performed from an evaluation of the updated model and an extrapolation on prior updates. We develop and implement the method for the Selective Melting Laser process with experimental observations given by a thermal camera. Numericals experiments show that this hybrid method significantly reduces the online computational time while providing relevant state evaluations and predictions.

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