A Bayesian Statistical Approach to Decision Support for TNO OLYMPUS Well Control Optimisation under Uncertainty

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Summary

Well control and field development optimisation are tasks of increasing importance within the petroleum industry, as seen by the development of and large participation in the 2018 TNO OLYMPUS Field Development Optimisation Challenge. Complex mathematical computer models, in the form of reservoir simulators, are used in the TNO Challenge as well as throughout the petroleum industry both to improve the understanding of the behaviour of oil fields, as well as to guide future decisions for well control strategies and field development.

Major limitations involved when using reservoir simulators include their complex structure; high-dimensional parameter spaces and large number of unknown model parameters; which is further compounded by their long evaluation times. The process of making decisions is commonly misrepresented as an optimisation task that frequently requires a large number of simulator evaluations, thus rendering many traditional optimisation methods intractable. Further complications arise due to the presence of many sources of uncertainty that are inherent within the modelling process such as those represented by model discrepancy. This makes it unwise to focus on a single best decision strategy that is potentially non-robust to such uncertainties.

We develop a novel iterative decision support strategy which imitates the Bayesian history matching procedure, that identifies a robust class of well control strategies. This incorporates Bayes linear emulators which provide fast and efficient statistical approximations to the computer model permitting the full exploration of the vast array of potential well control or field development strategies. The framework also includes additional sources of uncertainty such as model discrepancy which are accurately quantified to link the sophisticated computer model and the actual system and hence obtain robust and realistic decisions for the real oil field.

The developed iterative approach to decision support is demonstrated via an application to the well control problem of the TNO OLYMPUS Challenge. Accurate emulators are constructed using limited information from a relatively small number of simulations. Moreover, a variety of sources of uncertainty including many not considered by the TNO dataset are incorporated, their importance highlighted and their effects on the sensitivity of potential decisions demonstrated. Greater emulator accuracy is achieved at later waves due to iterative refocusing. This approach yields a collection of decisions which are robust to uncertainty for a greatly reduced computational cost compared to methods using the simulator only.