University of Stuttgart
Germany

Department for Stochastic Simulation
and Safety Research for Hydrosystems (LS3/IWS)

Analytic Computing (IPVS)

Bayesian meta-model and language for scientific modelling

M.Sc. Topic

In physics-based modelling and in physics-informed machine learning, many uncertainties exist. These range from imprecision in data used as boundary conditions or used for calibration/training, over uncertainties in parameter values even after calibration up to uncertainty about the conceptual structure of model equations. The Bayesian modelling paradigm is a highly useful statistical framework for addressing such uncertainties. Its strength is that modellers can specify uncertainties and information for all aspects of a model and data, and update this state of knowledge whenever new data or evidence occurs.

The strength of Bayesian modelling is also its weakness: it is asking a lot of expertise from modellers in exactly voicing what they know and what they do not know; for complex modelling tasks this can be very complex.

Constructing a logical modelling language and a formal representation for the logics of science during modelling requires two main ingredients. The first one is the “modelling meta-language”, which will be based on a meta-model concept of information in (Bayesian) modelling, which allows domain experts to express their knowledge, uncertainties and hypotheses as plain-language statements. The second ingredient is a formal representation of what a modeler expresses in that language – a concept we will call a Bayesian logics graph (BLG). BLGs are an extension of so-called knowledge graphs. It will be a directed graph that will formalize the existence of variables and corresponding observation data, causality among variables, classes of relations between quantities (e.g. linear, monotonic,…), identities or proposals for relations and suspected actual values. The graph will also be equipped with expressions of “strength of belief” in the Bayesian sense, e.g. with probability distributions. In this project, we will focus on the first task, which is developing the meta-language-model.

Prospective Tasks

- Literature review of knowledge graph and Bayesian methods
- Building a meta-model for information in scientific modelling
- Developing the logical modelling language

Supervision

- LS3: Bayesian modelling, domain expertise, modelling logics, symbolic regression application
  Timothy Praditia, Dr. Dipl.-Ing. Anneli Guthke, apl. Prof. Dr.-Ing. Sergey Oladyshkin, Prof. Dr.-Ing. Wolfgang Nowak
- IPVS: Meta-Models, domain languages, knowledge graphs
  Alexandra Baier, Daniel Frank, Prof. Dr. Steffen Staab

Desirable skills

- Good knowledge on machine learning and Bayesian statistics
- Affinity to numerical simulations and programming

Apply now!
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