Realising the Uncertainty Enabled Model Web

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What is the Uncertainty Enabled Model Web?

UncertWeb is an EC funded project (2010-2013) building the uncertainty enabled model web. The model web is a developing concept. Models and data resources are exposed as web services which can be integrated to provide new composite models (workflows) that enable us to answer more complex questions. Component models can be modified and replaced so long as the interfaces stay the same. In what exists today there is little attention paid to uncertainty in models and data. UncertWeb adds support for uncertainty quantification and propagation to provide quantitative measures of the quality of the outputs of the workflows. This is essential for rational decision making and optimal policy formulation. The UncertWeb framework consists of a series of profiles of Open Geospatial Consortium (OGC) information models, service interfaces and a set of Web-based tools to support uncertainty management and communication.

UncertML 2.0

UncertML 2.0 is a conceptual model, a controlled vocabulary and a set of encodings (currently in XML, JSON and netCDF) for representing uncertain values. Associated Java and R APIs provide encoding/decoding and manipulation functionality. The model is designed to be easy to use and can be used flexibly across multiple domains.

A more complete example: uncertainty in future food supply in the UK under climate change

To demonstrate the utility of the methods developed in UncertWeb we are deploying the framework in a number of application domains. One domain where uncertainty is an important factor is the issue of food security under a changing climate. The uncertainties in this scenario arise from many causes, including both epistemic and aleatory sources. The model workflow consists of 3 core models for: a) estimating land-use practices; b) simulating future land-use scenarios and c) predicting the crop yield. The models are run at field level and consider uncertainty in farmer behaviour, model parameters, climate projections and emulator approximation. The workflow uses the UncertWeb tools shown below. Data is mostly stored in an uncertainty enabled Sensor Observation Service and a dedicated workflow has been created. This work is done in collaboration with Jill Johnson, Sarah Knight and John Paul Gosling at the UK Food and Environment Research Agency.

Elicitation of Uncertainty

An \textit{a priori} estimate of uncertainty is often not available for variables in a model workflow. UncertWeb has developed the Elicitator to enable web based expert elicitation. The Elicitator allows users to define elicitation problems, make them available to experts using the system to manage interaction and pool the expert judgements.

Managing Uncertainty

UncertWeb has developed tools to assist users in managing uncertainty, in particular to undertake variance based (global) sensitivity analysis. The tool also permits the creation of statistical surrogate models, or emulators, using sophisticated statistical methods to improve computational speed.

The tool also allows the emulators to be deployed automatically as SOAP/WSDL services. It is limited to models with simple inputs at present.

Visualising Uncertainty

Once the model workflow has been executed, the visualisation tools can help you understand and communicate uncertainty in the outputs. The tool supports the UncertWeb O&M and NetCDF-U formats.

Future Directions

UncertWeb is building a framework and four example uncertainty enabled workflows in biodiversity, agriculture, air quality and personal mobility domains. Within UncertWeb, partner CNR are also developing a Composition as a Service metaphor to assist in integrating diverse service interfaces within a workflow execution engine in a brokering framework. The complexity of managing the variety of model deployments and information models to communicate between models is a real barrier to effective model integration. The model web concept also faces other significant challenges: integration with other modelling frameworks (e.g. OpenMI, Taverna) and cost to model owners. We believe that simplicity is key here. However community level agreement on model interfaces and information models remains a long way off, and the variety of frameworks, to which we have added, does not improve the situation. Future development of the model web should focus strongly on integration of existing frameworks within a common conceptual model. Any further development should support the management of uncertainty - without this capability, workflow quality is unknown and rational decision making is impossible.

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Further information: http://www.uncertweb.org