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Article 3

A Generic Multi-scale Modeling Framework for Reactive Observing Systems: An Overview

Summary:

This paper describes a conceptual model based framework for implementing Reactive Observation Systems (ROS). The primary goal of ROS is to help in the verification of hypothesis, based on information collected from the environment. A ROS consists of sensors embedded in the environment (mobile and stationary) and has the capability to adjust how it acquires input based on previous observations.

The framework proposed in this paper is called AMBROSia which stands for Autonomous Model-Based Reactive Observing System. The framework facilitates the construction of a system based on inter-related models which have different space- time scope. The models allow predictions which enable more relevant data collection. This optimized data collection allows further refinement of the model.

In order to demonstrate an application of the framework to a real-world problem, the paper has described its use in monitoring marine ecosystems. The long term goal of this application is to understand and predict the conditions under which certain marine micro-organisms develop. In particular the focus is on micro-organisms which have a significantly adverse affect on marine ecology, human life and the economy.

The study of marine micro-organisms in their natural environment poses some significant problems. The first major challenge is locating the microbes of interest, because the domain under study includes large marine environments such as coastal areas, reservoirs etc. Secondly, microbe populations can migrate because of wind and wave action. To address these issues a large network of static sensors is used to detect colonies and a second set of mobile sensors track the colonies as they drift. These mobile sensors allow a denser sampling of the environmental conditions in the region of interest. They can also collect samples of the microbe population for study in a laboratory.

The AMBROSia framework is divided into three major layers, the sampling and optimization control layer, the model construction, selection and adaptation layer and the model lookup layer. The sampling and optimization layer reconfigures the system to optimize data collection. Optimization decisions are influenced by the predictions made by the models. Next is the model construction, selection and adaptation layer. This layer is responsible for constructing a composite model from measurement models, which are local to a sensor and external models supplied by human experts. The model lookup layer queries the sensors for their measurement models, in response to requests by the model construction layer.

Application of DDDAS:

The AMBROSia framework utilizes DDDAS in the way its external sensors, both static and dynamic, interact with the internal prediction models provided by the system. The data collected by the static sensors informs the prediction models, which determine where to send the dynamic sensors. The additional data collected by the dynamic sensors is used to refine the prediction models so that they provide more accurate predictions for making future measurements. Data dynamically collected by the sensors refines the accuracy of the simulation, which in turn improves the effectiveness of the data collection. This is clearly an application of DDDAS.

Ways to Improve DDDAS Application:

When the AMBROSia framework updates its composite prediction models, it is not clear how or if the human supplied models are adjusted. If the only models being adjusted by the system are the measurement models, while the models supplied by human models remain static, there is a possibility that human error in the supplied models could hinder prediction accuracy despite having better and better measurement models. The article does not discuss how the human supplied models are represented in any detail and the feasibility of updating them with information from collected data.