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ARTIFICIAL INTELLIGENCE MEETS MISSION CONTROL: THEORY AND APPLICATION OF DYNAMIC BAYESIAN NETWORKS

Abstract

In this work an alternative approach to Mission Control will be discussed from a data analytical perspective and its mathematical foundations in the framework of Probabilistic Graphical Models, based on a research internship at ESA's European Space Operations Centre. The goal lies in a combination of detecting anomalies within one timeseries, forecasting the spacecraft dynamics and setting new perspectives on dependency investigations among multiple parameters. Since this work is an invesitgation of both, theory and application of Dynamic Bayesian Networks in Mission Control, thus, it is devided into 2 parts:

In part I, at first, a general overview and basic ideas in the notion of Dynamic Bayesian Networks will be presented. The primary goal will be, to gain an overall understanding of the underlying topics and relevant techniques. This involves the notion of Hidden Markov Models and the corresponding required algorithms. We emphasize, that the complexity of inference in Dynamic Bayesian Networks is NP-complete and we point out the particular advantages of an information theoretical perspective on Dynamic Bayesian Networks.

In part II, experimental results will be demonstrated in the context of Mission Control. For the sake of simplicity, the programming part will be executed for Hidden Markov Models, as a surrogate for Dynamic Bayesian Networks. We are going to set up preprocessing steps; and experimental results for forecasting and investigating anomalies will be presented.

Although the application in part II will be concentrated on Hidden Markov Models as a subclass of Dynamic Bayesian Networks, the theory in part I as well as the techniques used for the experimental results are universally valid for Dynamic Bayesian Networks and worthwhile relevant as a novel approach for ESA's European Space Operations Center.