Norwegian University of
Science and Technology,
NTNU

Faculty of Information Technology,
Mathematics and Electrical Engineering,
Department of Engineering Cybernetics (ITK)

Combined summer project and final year project assignment:

Predictive, parametric modeling for control applications

Name of candidate: Ugur Alpay Cenar
Professor/supervisor: Bjarne Foss, ITK, NTNU, Trondheim, Norway
Co-supervisor: Bjarne Grimstad, Solution Seeker AS, Oslo, Norway
Project start and end date: 10.06.2016 to 10.08.2016

In recent years we have seen a tremendous development in the field known as machine learning. The yield from this development is a wide array of new methods, practices and software for predictive modeling. Put simply, predictive modeling is the process of training and testing the predictive capabilities of models by using observations (sensor data) from some system of interest. This development conveniently coincides with a great increase in sensor data – a trend seen in almost all industries. The use of predictive modeling, or data-driven modeling techniques, may simplify the often time-demanding efforts required by traditional mechanistic modeling.

In control engineering, the above methods have until recently seen few applications. The reason for this has been that the class of nonparametric models, such as artificial neural networks (ANN) and random forests, are difficult to analyse due to their intrinsic complexity. Therefore, they have traditionally been considered unpredictable and not suited for control purposes [ref].

Another class of models is the parametric models, such as linear or polynomial models. In view of predictive modeling, a main difference between parametric and non-parametric models is that the practitioner must specify the *features* of a parametric model (for example the degree of a polynomial or the window-length of a moving average). Non-parametric models circumvents this by employing a very flexible model structure (such as the network of neurons in an ANN). A parametric model, having a known structure, is easier to analyse and incorporate into a control loop.

An advantage with predictive modeling is that the model error is estimated using resample techniques such as cross-validation or bootstrapping, or using a separate test dataset. Thus, the practitioner may with some certainty assess the accuracy of the model. This information can be used to device a robust control law.

In this work, the candidate shall investigate the use of predictive modeling techniques with parametric models to be used in control.

Task description:

- Perform a literature study on predictive modeling with a focus on parametric models. The study should put predictive modeling into the context of traditional model identification (subspace methods, etc.).
- Describe two or more test problems in which the following tasks should be performed. Suggested problems: a simple process with a tank; a casing-heading slugging problem using the model in Eikrem's PhD thesis [ref].

- Perform predictive modeling. The modeling should result in a parametric model suitable for control and with an estimated model error.
- Use the model to derive or improve the control loop. Optimal control should be considered.
- Investigate how the estimated model error can be utilized for robust control.
- Discuss the applicability of predictive modeling in control.

Note: an in-depth study of optimal and robust control with parametric models may be left for the MSc thesis work.

Trondheim, March 30, 2016.