Data driven diagnosis of complex systems

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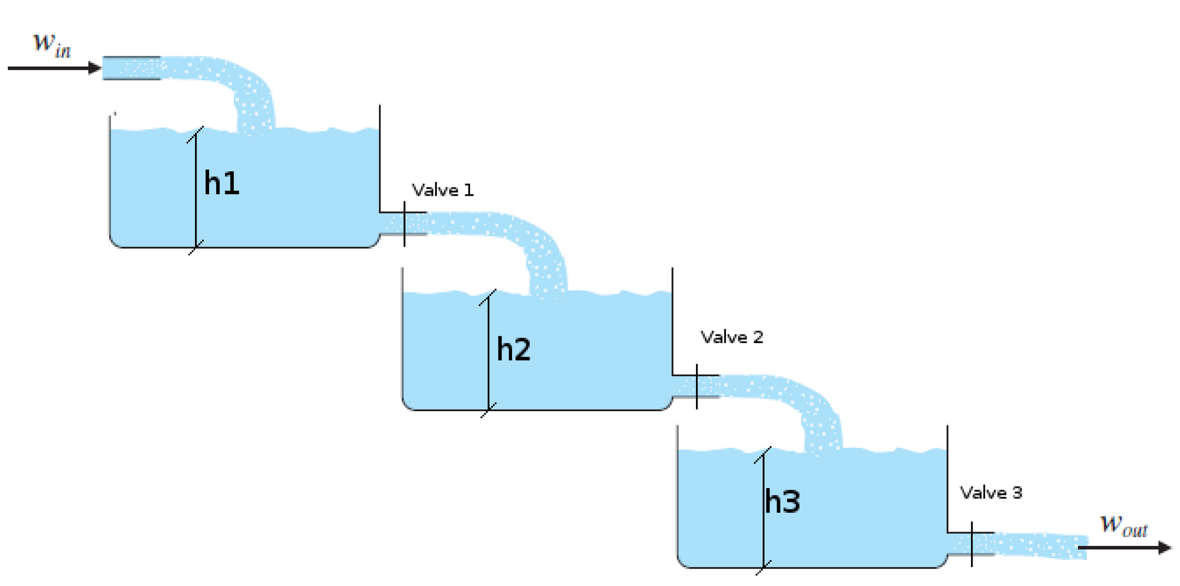
General Problem

Performing diagnosis on a complex system requires at least an efficient and accurate model of the system itself, which can then be used to run simulations useful to collect data for diagnosis. The problem is that running simulations on such high fidelity models requires time and high performance resources, which cannot always be available. For this reason we want to generate a simple model of the complex system based only on real data, provided by the system itself, and then use it to perform our analysis. From such simple models we will be able to retrieve all information of the system requried to perform fault diagnosis on it. The data driven approach has attracted attention in the last years proving that it is an efficient and effective tool for these type of problems, but other methods are still used, such as hierarchical and reduced models (approaches that we are not going to consider).

Real problem: liquid flow through three tanks



Differential Equations:

$$\delta(h_i) = \frac{in_i - out_i}{h_{max}}$$

Approximated Linear Model:

$$System \simeq f(Data, Model, Constraints)$$

Fault Diagnosis:

- Pattern recognition
- Machine learning techniques
- ?_?

Approach

Our goal is to create a framework able to create a diagnoser of the system under observation, only providing the data of its behaviour, either correct or faulty.

Model generation

The data driven model creation can be done using different approaches, from polynomial approaches to machine learning methods. The selection of the appropriate model to use will be done through an optimization problem based on *Accuracy* and *Computational Costs* of each model.

$$J(\cdot) = \alpha\ Accuracy(\cdot) + \beta\ Computational\ Cost(\cdot)$$

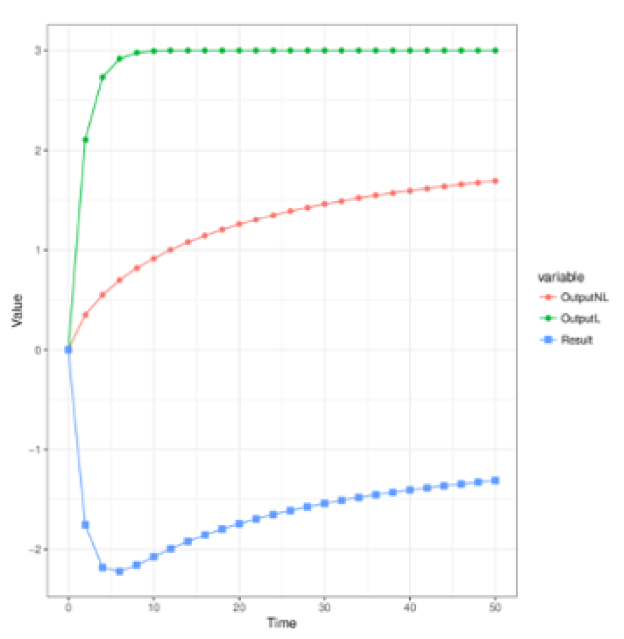
Diagnosis

In respect to the error classification and recognition, a Neural Network or a series of Support Vector Machines will be implemeted to deal with the errors in the system behaviour.

Achievements

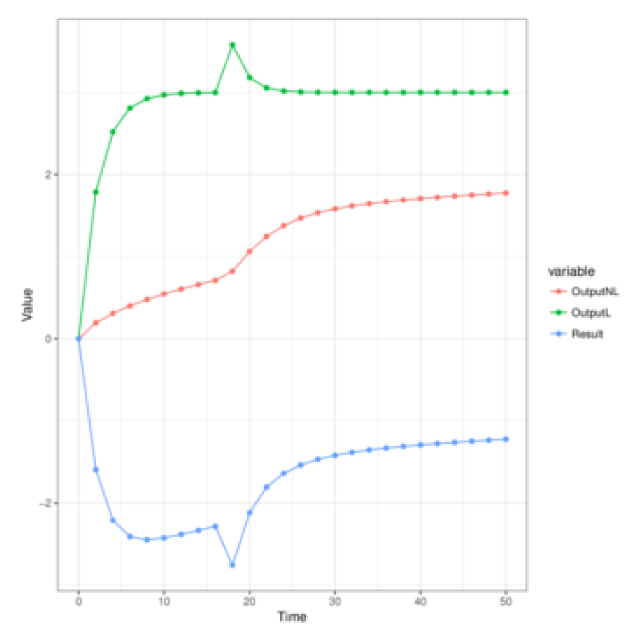
Currently we are able to generate a linear model from the data of a high-fidelity model. Such models, or *Corrective models*, properly approximate the behaviour of the high-fidelity models in each scenario separatedly, will that either be a normal or faulty behaviour. The purpose of these corrective models have been extended to a more general scenario and try to generate the best models which can predict how to behave in each possible faulty situation.

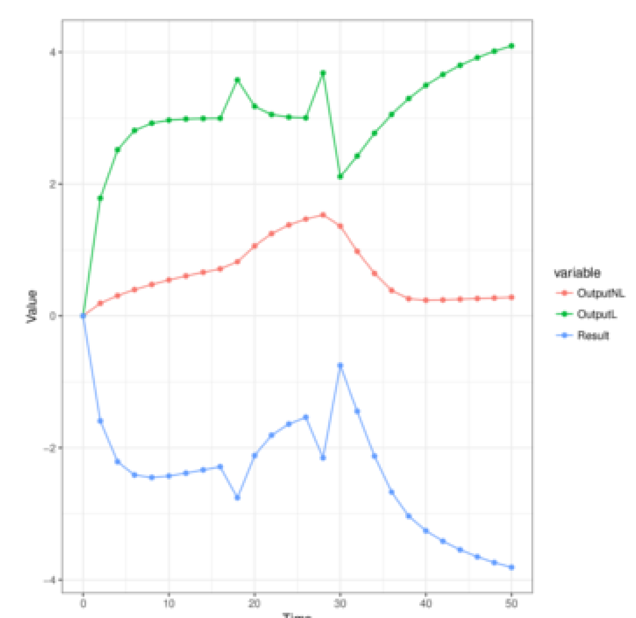
Corrective functions



Normal behaviour

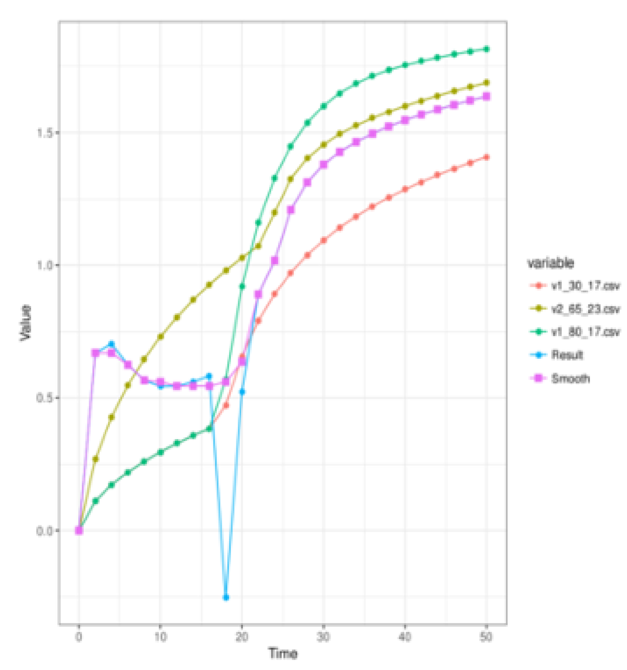
Problem to one valve





Problem to two valves

Problems over multi simulations



Next steps

We are now trying to incorporate some basic machine learning concepts to our framework for the model generation, which will lead us to find which model is best to be used for a particular problem.