NIgreyfast: toolbox for nonlinear grey-box identification

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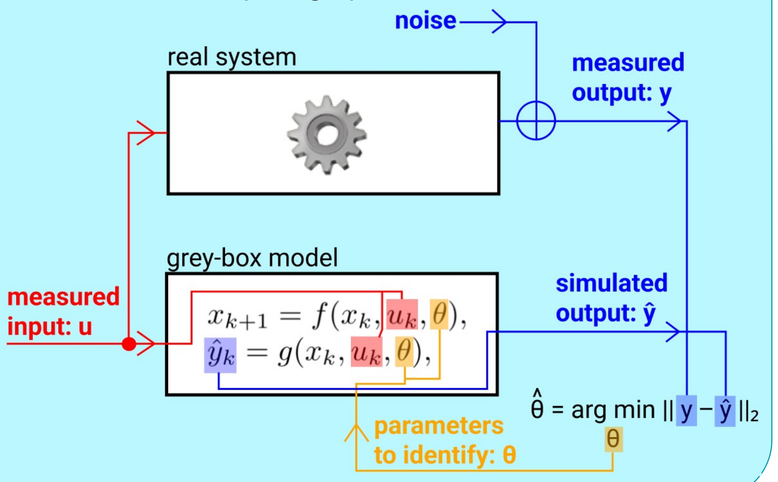
Robust adaptive control

DMMS-M core lab

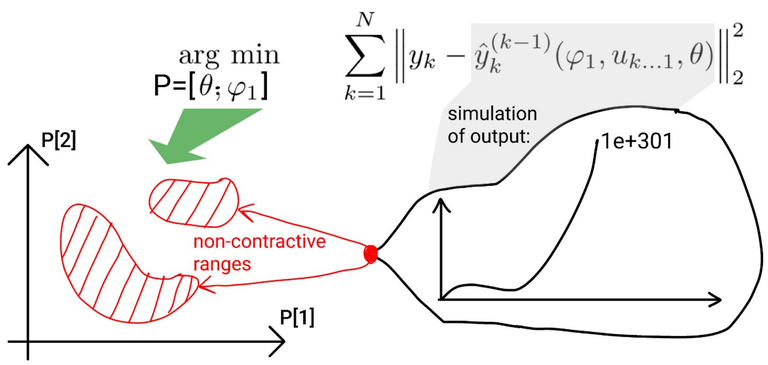
Goal

Robust and fast methods for offline and online identification of nonlinear state-space grey-box models:



Motivation

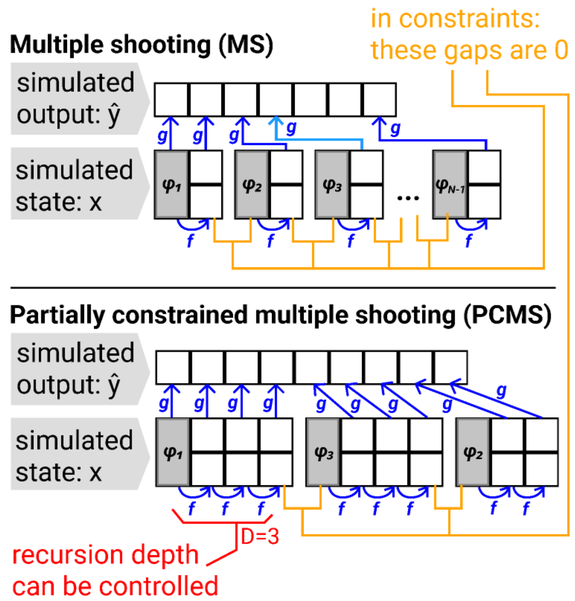
In the single shooting (SS) formulation (as in, for example, the MathWorks System Identification Toolbox), for certain models, the output response of the model might become non-contractive (unstable) for certain value ranges of the decision variables:



If the solver takes a step into such a parameter range, it fails and the optimization cannot continue. Furthermore, the solver easily gets trapped into a local minimum. We wanted to increase the robustness against such situations.

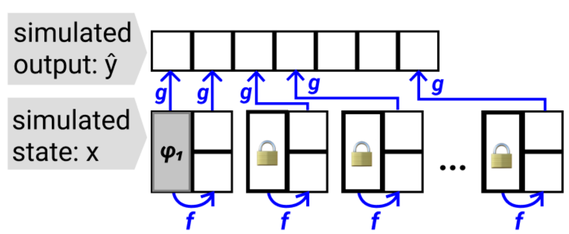
Approach

We use different formulations of the optimization problem that are more robust to a non-contractive initialization for the parameters and initial states:



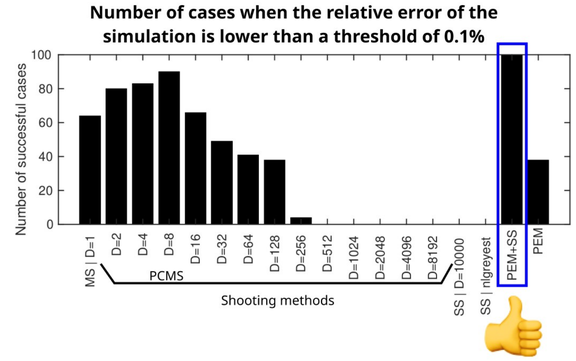
Using multiple-shooting-type formulations, it is possible to pass previously non-contractive parameter ranges, but these are computationally heavy because of the additional constraints and decision variables. The partially constrained method allows to find a compromise between robustness and computational complexity.

If we can measure or infer (e.g. position → velocity) how the states evolve, then we can:
- use it as an initial value for φ in MS/PCMS,
- minimize the 1-step-ahead prediction error (PEM):



Results

We have compared all the methods at 100 simulated experiments on an electromechanical positioning system, and **subsequently applying PEM and SS methods was the most robust** against a non-contractive initialization:



We have released the implementation of all methods as an **open-source toolbox on GitHub**:
https://github.com/meco-group/nlgreyfast

It's also **fast**: we have compared this toolbox with the MathWorks System Identification Toolbox on the SS case, and it was able to solve the same set of problems in an order of magnitude less running time.

Key take-aways

Check out our toolbox for fast and robust methods to solve nonlinear grey-box identification problems. →

This toolbox can also take into account that some or all of the states can be directly measured/inferred.

Further reading

A. Retzler, J. Swevers, J. Gillis and Zs. Kollár, "Shooting methods for identification of nonlinear state-space grey-box models", IEEE 17th International Conference on Advanced Motion Control, Padova, Italy, 2022.