Derivative-Free Optimization by Model-Free Control Approach

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A "model-free" -based robust controller

- A class of robust controllers that does not need the model to be adjusted. Extension of the original model-free control approach to the control of switched nonlinear systems and the control of non-minimum phase systems.
- We define a control law that estimates the model to control only from the output reference and the output measurements.
- From an unknown model seen as a "general model" $y = E(u)$:

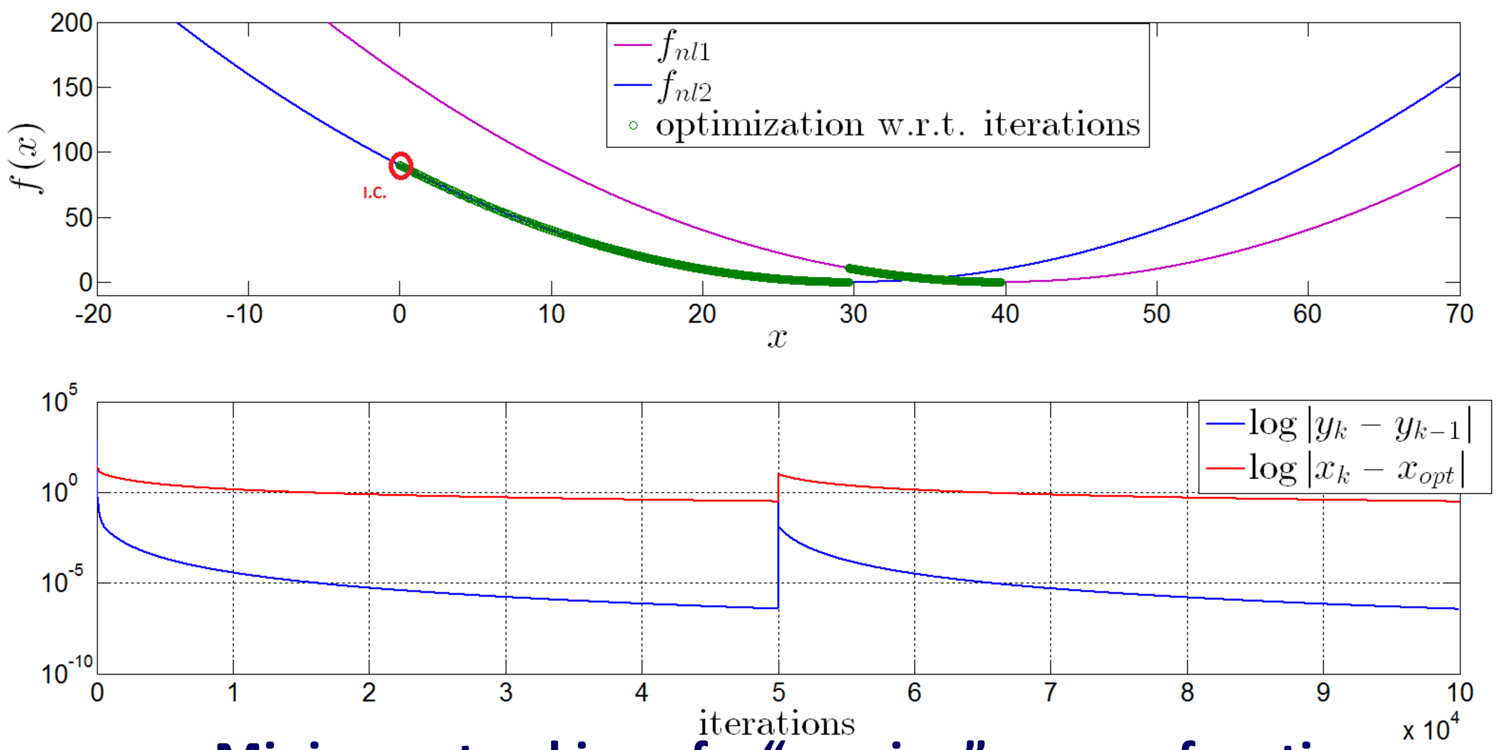
$$E(y, \dot{y}, \cdots, y^{(a)}, u, \dot{u}, \cdots, u^{(b)}) = 0$$

we construct the discrete derivative-free & model-free controller that controls the unknown model E :

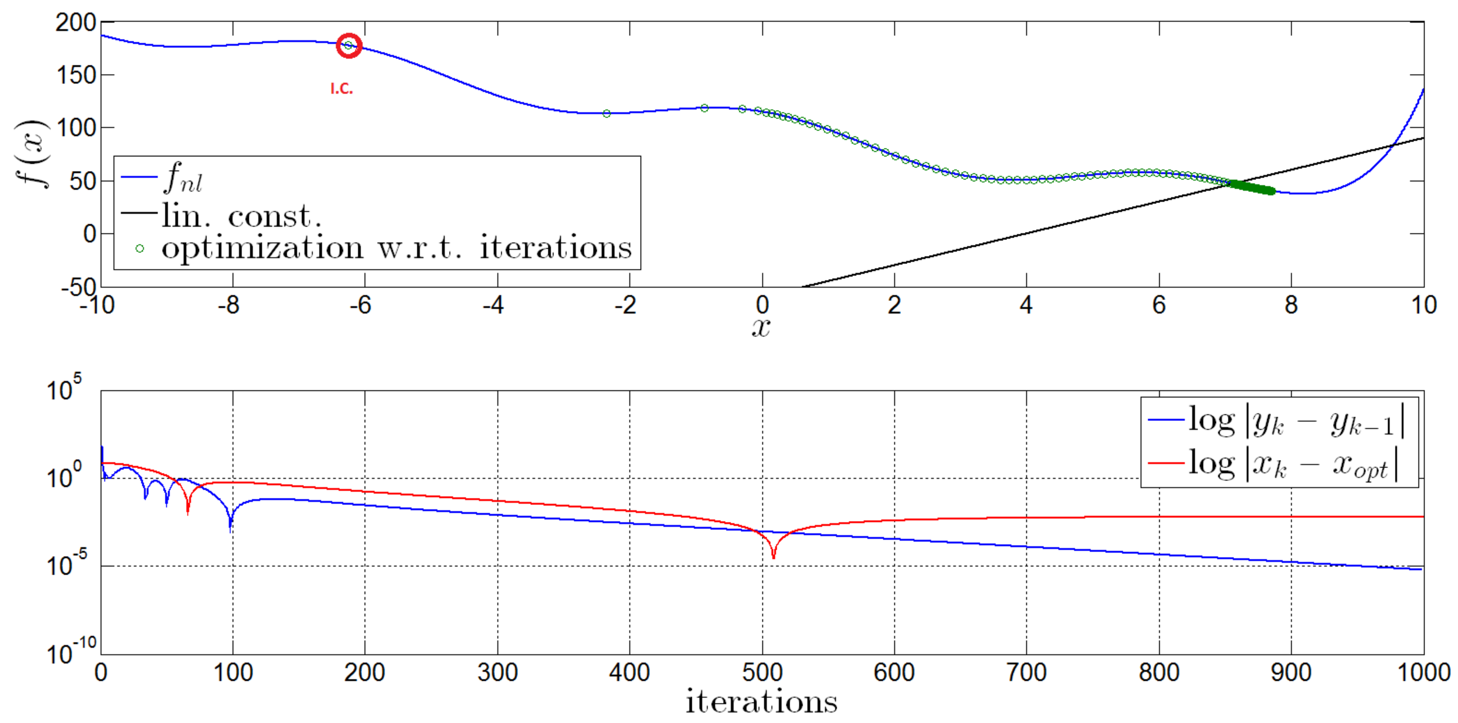
$$(y, y^*) \mapsto u_k = \int_0^t K_i \varepsilon_{k-1} d\tau \Big|_{k-1} \{u_{k-1} + K_p(\alpha e^{-\beta k} - y_{k-1})\}$$

where K_i, K_p are tuning gains and α and β are positive real constant.

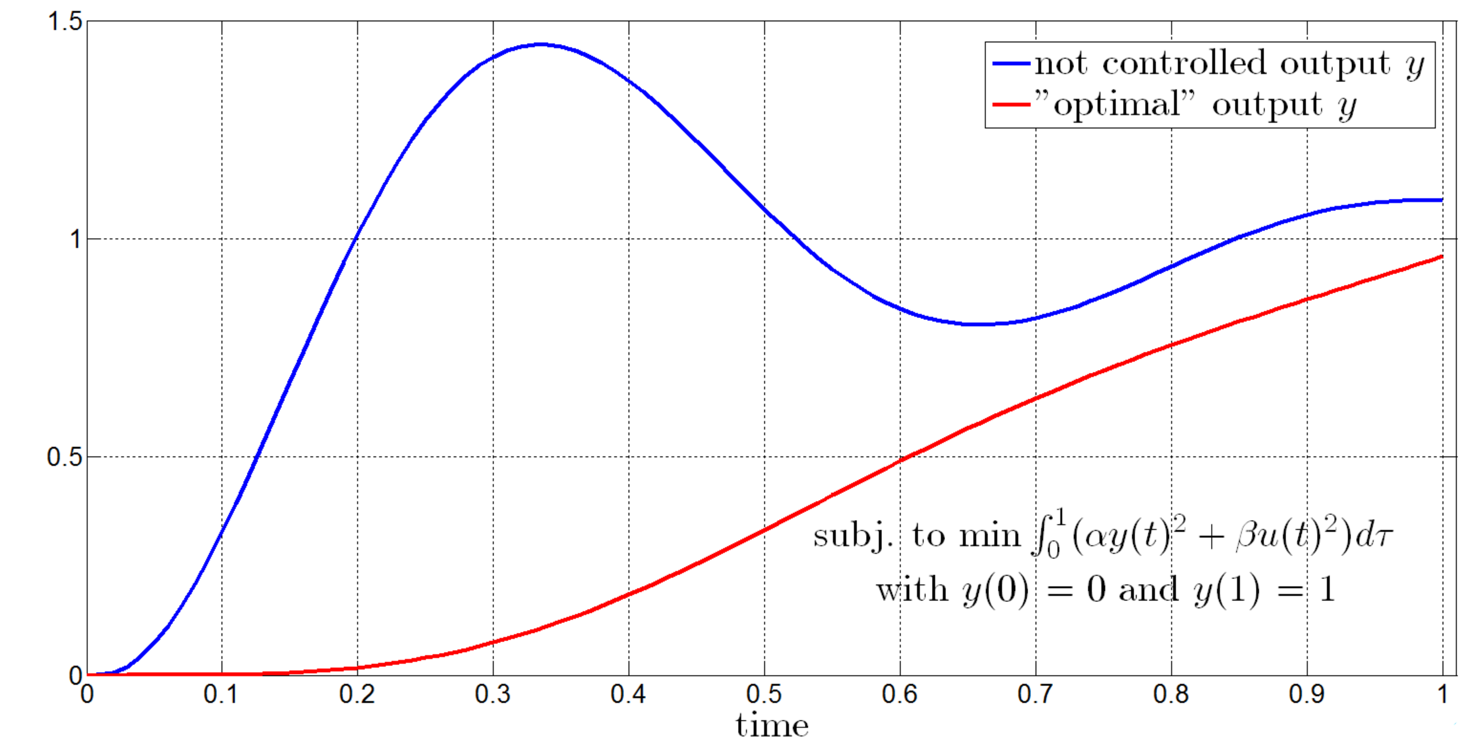
Some examples



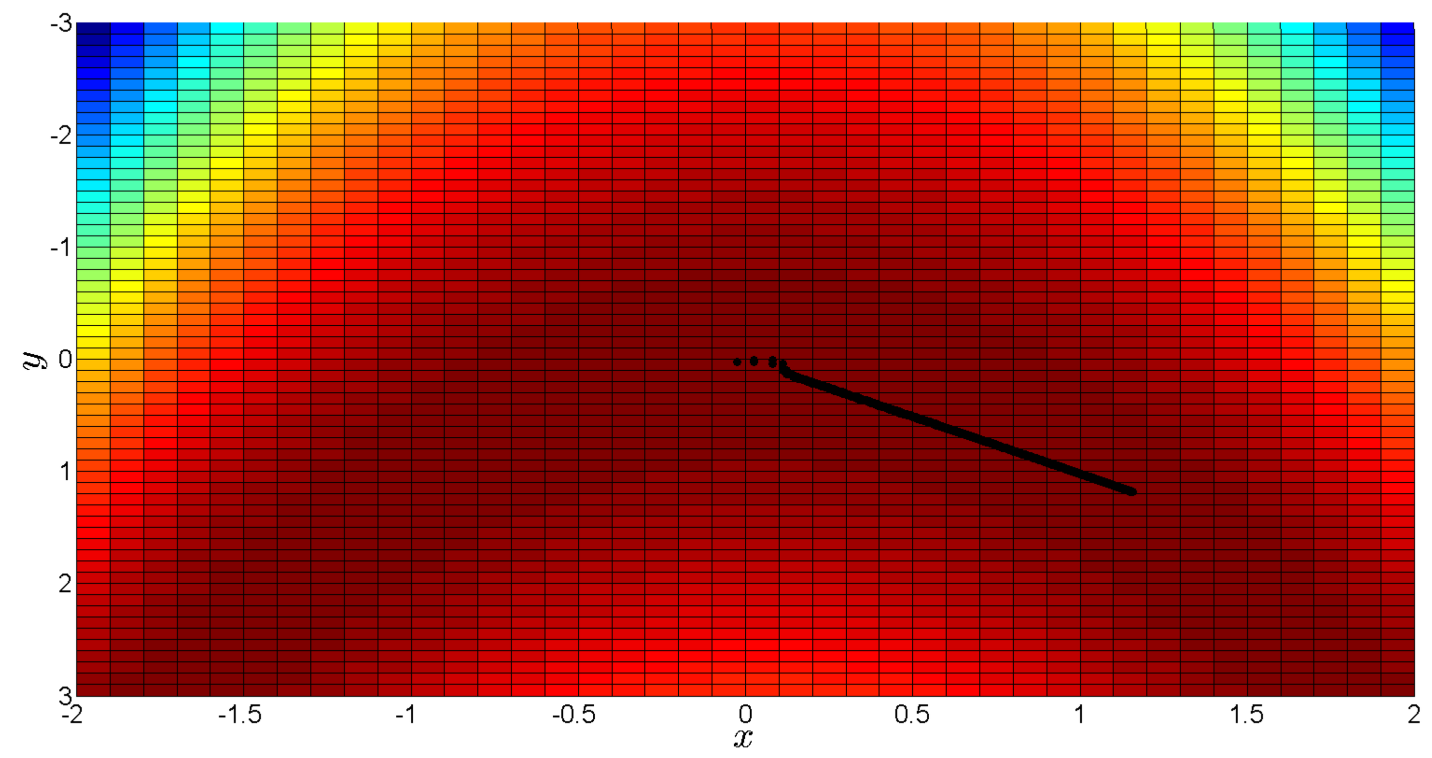
Minimum tracking of a "moving" convex function



Minimum tracking of a nonconvex function with constraints



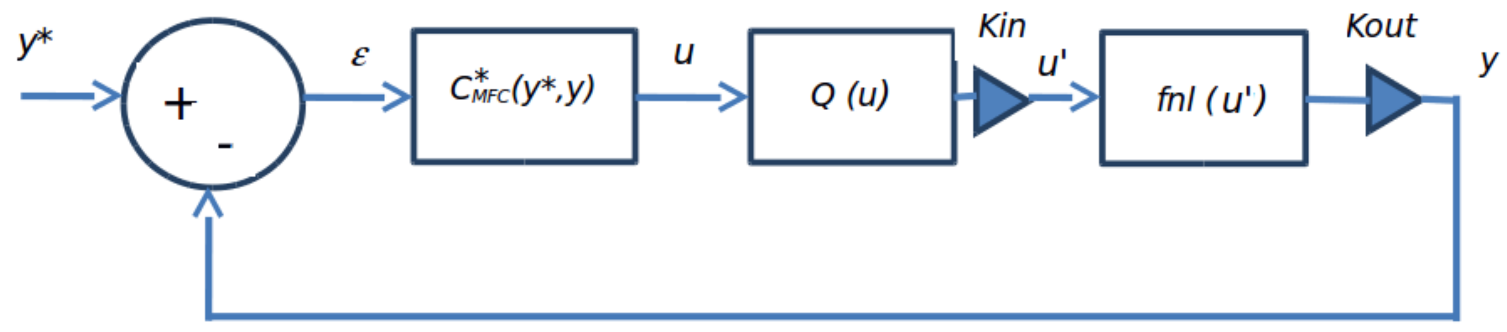
Optimal control of a linear dynamical system



Minimum tracking of the Rosenbrock function

Application to Derivative-Free Optimization

- Transposition of the "model-free" controller to an "extremum seeking procedure"



Q is a first order function ; *C_{MFC}* is the proposed controller

- Main Goal : Looking for the minimum of the function f_{NL} in real-time eventually under constraints.

Further investigations…

- Proving the asymptotic stability using e.g. the Input-to-State Stability concept that gives in addition an estimation of the convergence rate.
- Generalization to complex systems e.g. application to optimal control considering integral criteria to minimize.

References

- A. Conn, K. Scheinberg, L. Vicente, **"**Introduction to Derivative-Free Optimization **"** , SIAM book, 2009.
- M. Fliess and C. Join, « Model-Free Control », Int. Journal of Control, Vol. 86, Issue 12, 2013.
- L. Michel, **"**A Unified Model-Free Controller for Switching Minimum Phase, Non-Minimum Phase and Time-Delay Systems**"**, preprint ArXiv, Feb. 2012.