Implementing MPC Using Deep Learning

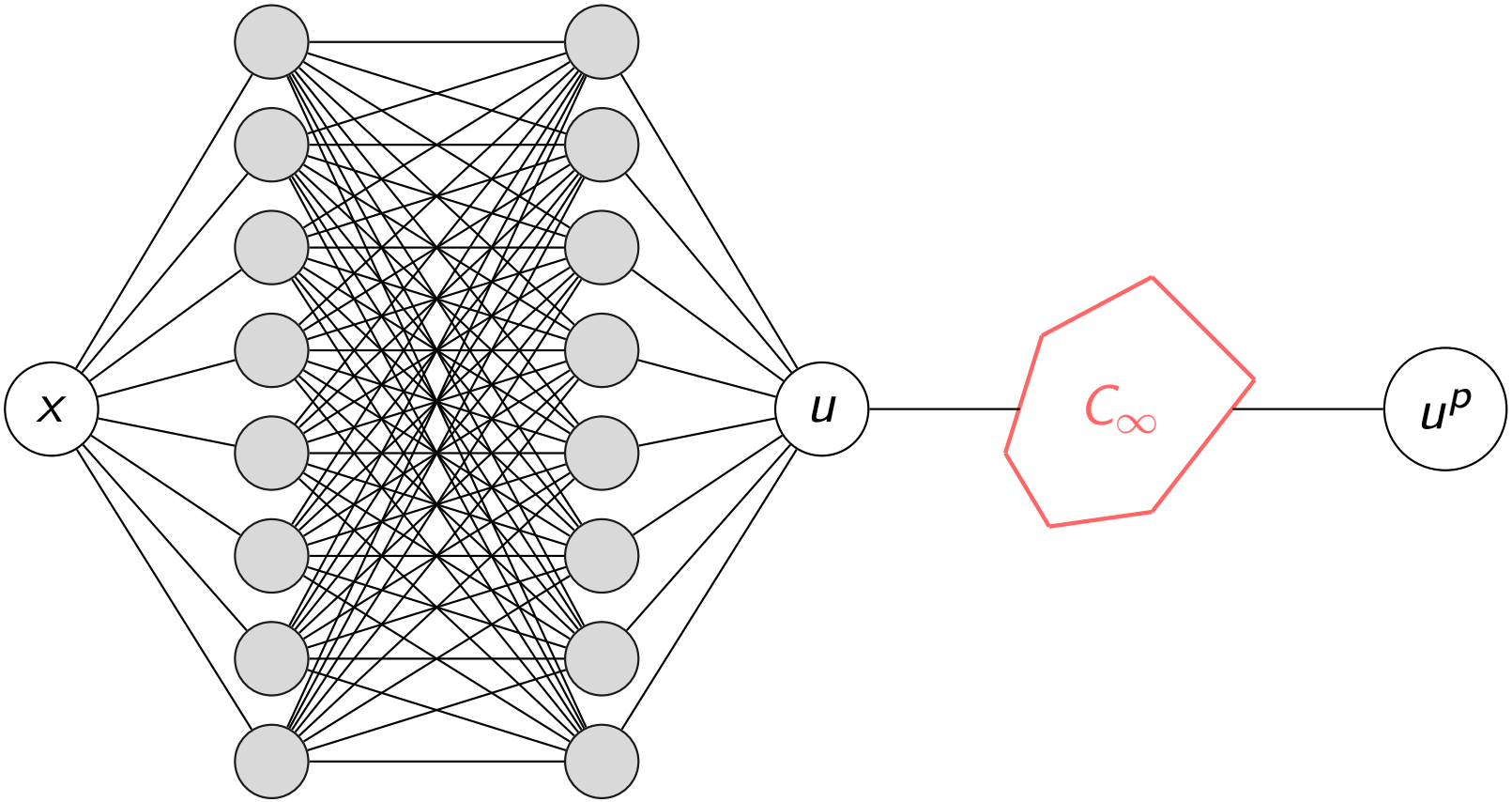
Rebecka Winqvist

Review

- Approaches
  - Constrained Neural Networks[1]
  - Primal Active Sets[2]
  - Long Short Term Memory (LSTM) supported NN[3]
- Optimization layers
  - OptNet[4]
  - Cvxpy-layers[5]

[1] Approximating Explicit Model Predictive Control Using Constrained Neural Networks
[2] Large Scale Model Predictive Control with Neural Networks and Primal Active Sets
[3] A Deep Learning Architecture for Predictive Control
[4] OptNet: Differentiable Optimization as a Layer in Neural Networks
[5] Differentiable Convex Optimization Layers

Current implementation



Data generation

- Gridding
- Hit and Run (HAR) algorithm
  1. Pick starting point, x_0, in the feasible region, S;
  2. Randomize a direction, d;
  3. Randomize a distance, λ, to walk in d, s.t. $x_0 + \lambda d \in S$;
  4. Set $x_1 = x_0 + \lambda d$
- OSQP as solver

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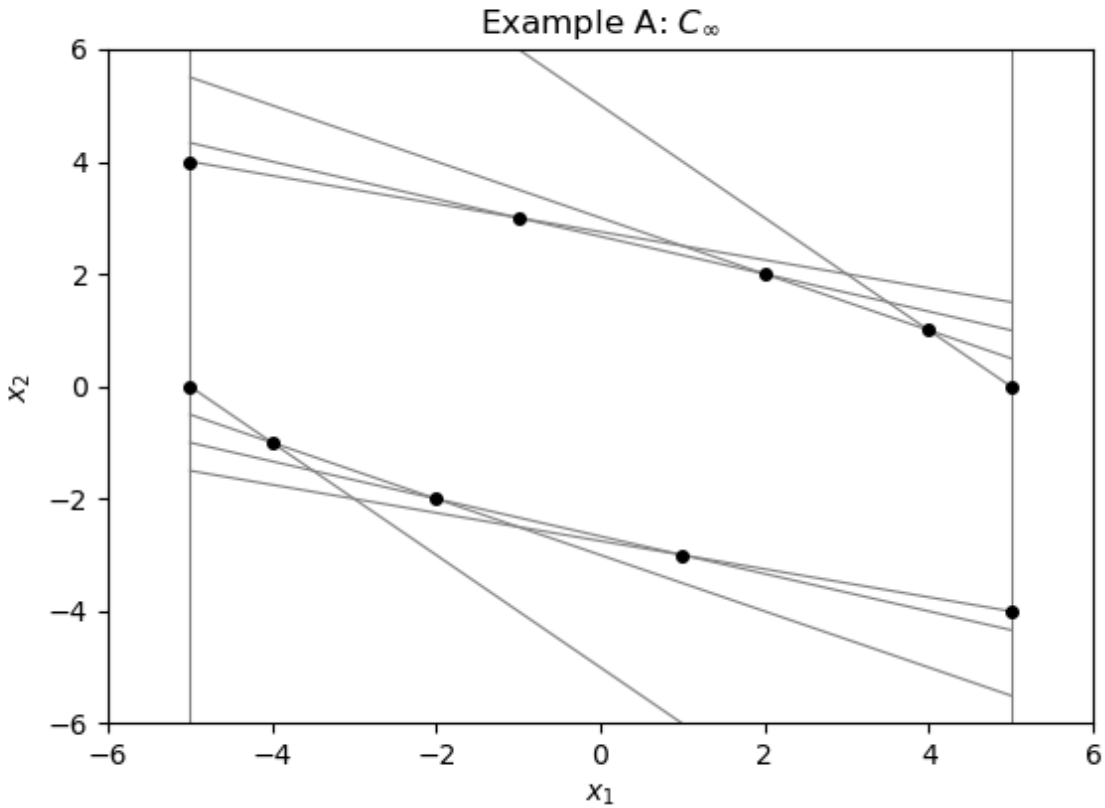
Example

Double integrator

$$x_{k+1} = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} x_k + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u_k, \quad \begin{bmatrix} -5 \\ -5 \end{bmatrix} \leq x \leq \begin{bmatrix} 5 \\ 5 \end{bmatrix}, \quad |u| \leq 1$$



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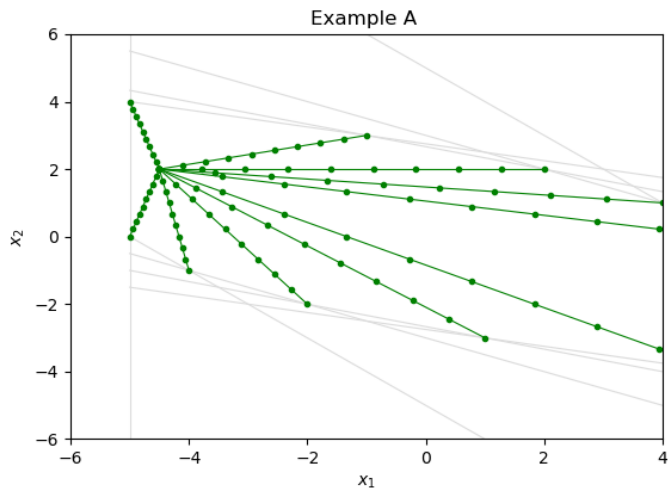

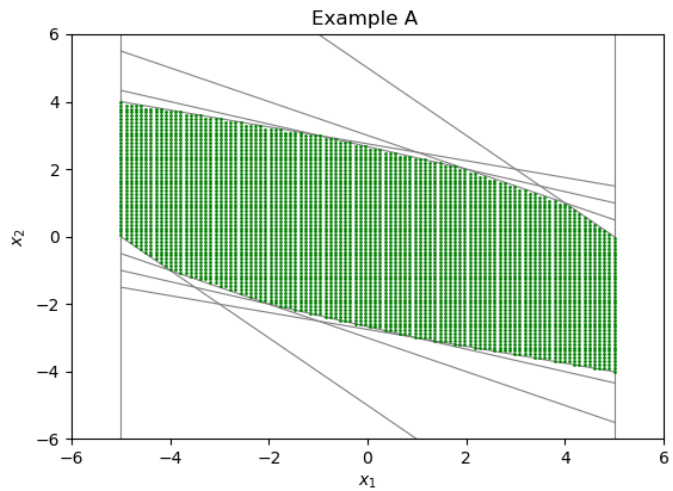

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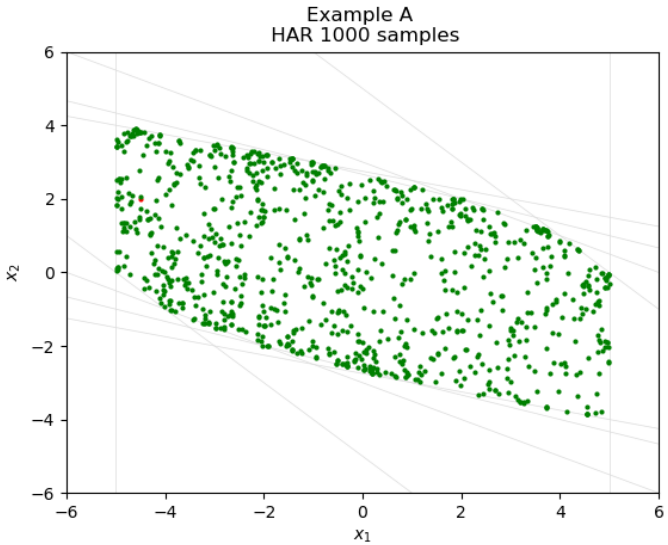

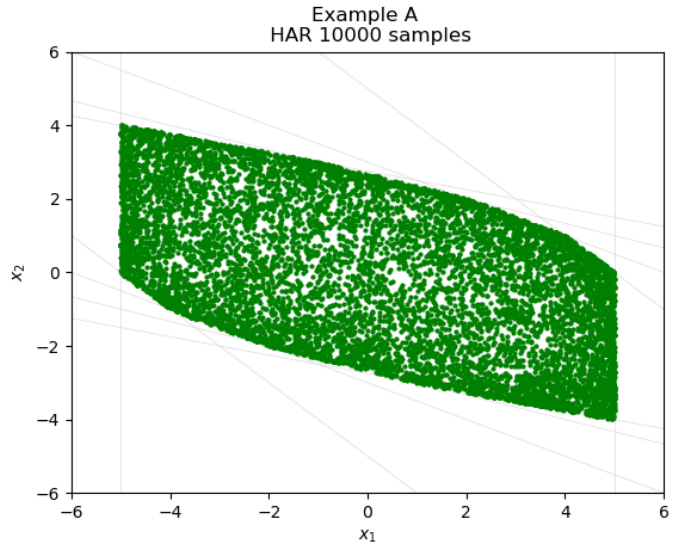

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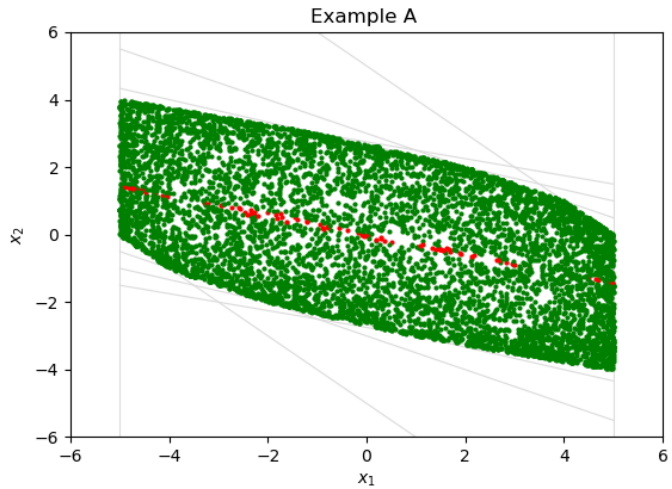
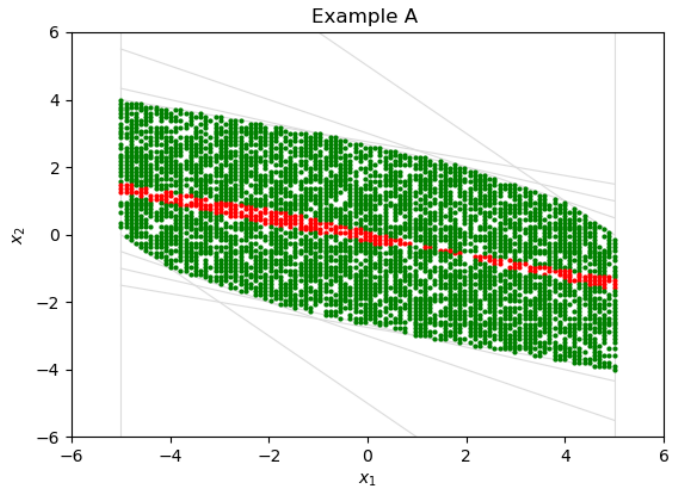


(e) HAR 10 000 samples.



(f) GRID.

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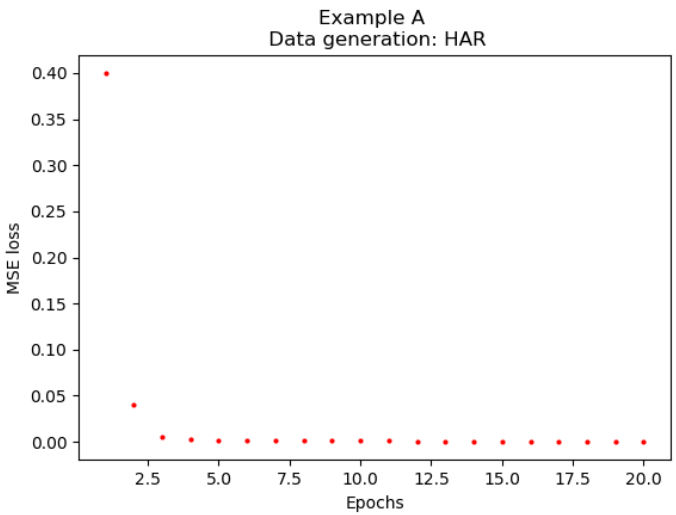

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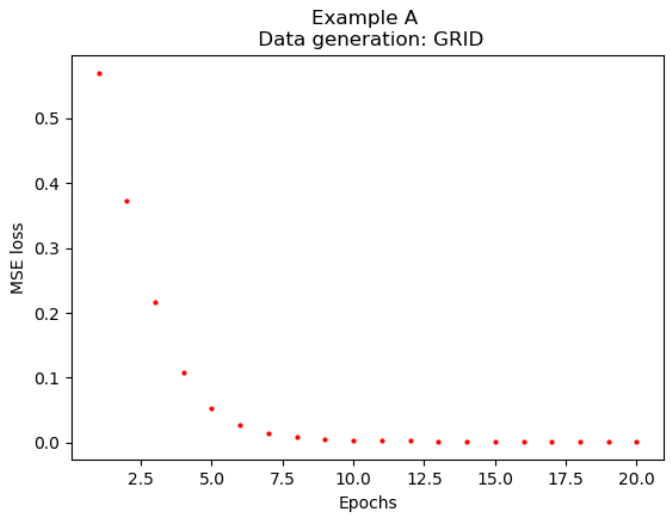

(h) GRID.