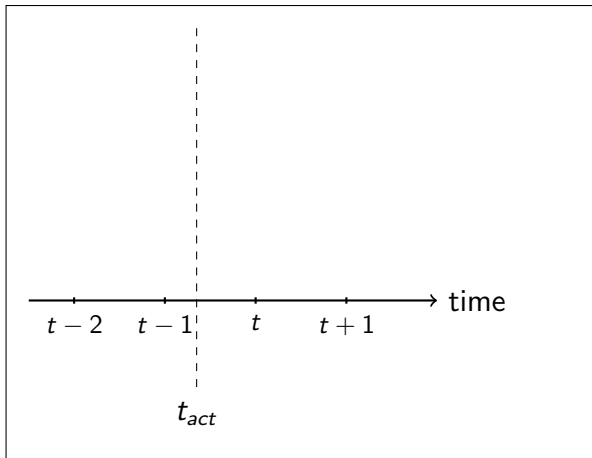
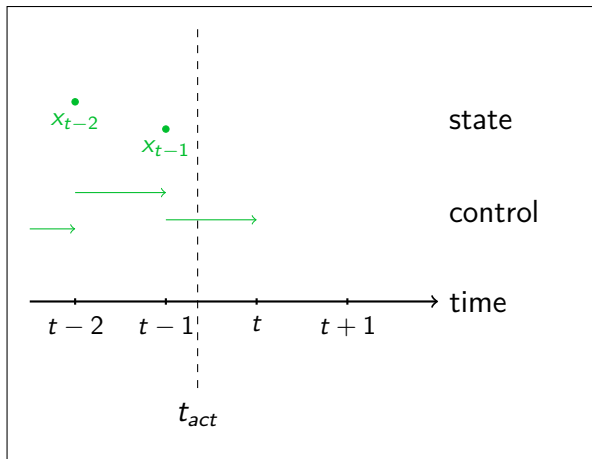


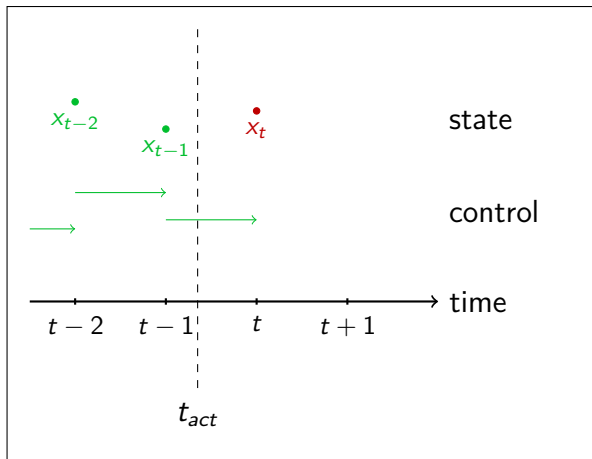
Setting



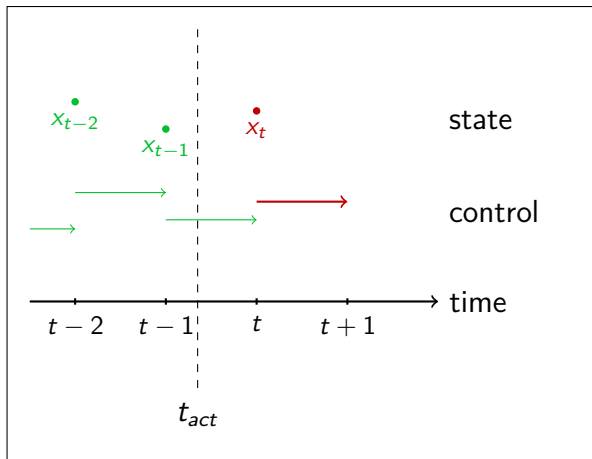
Setting



Setting



Setting



Discrete Problem

$$\min_{x,u} \sum_{i=t}^N J_i(x_i, u_i) \quad \text{s.t.} \quad h_i(x_i, u_i) = 0 \quad i = t, \dots, N$$

$J_i(x_i, u_i)$ discretized goal function

$h_i(x_i, u_i)$ equality condition at time i

The Lagrangian

$$L^t(y) = \sum_{i=t}^N J_i(x_i, u_i) + \sum_{i=t}^N \lambda_i^T h_i(x_i, u_i)$$

$$y := (\lambda, x, u)$$

$$y^* \text{ optimal} \Leftrightarrow \nabla_y L^t(y^*) = 0$$

The SQP Method

Find y^* :

$$y_{k+1} = y_k + s_k$$

$$\min_{s_k} \frac{1}{2} s_k^T \nabla^2 L(y_k) s_k + \nabla L(y_k)^T s_k$$

Quasi Newton-Method

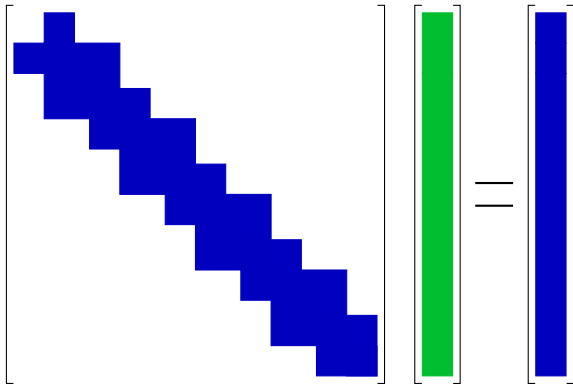
Find s_k with:

$$\nabla L(y_k) + \nabla^2 L(y_k) s_k = 0$$

Approximate $\nabla^2 L(y_k)$ and solve:

$$H(y_k) s_k = -\nabla L(y_k)$$

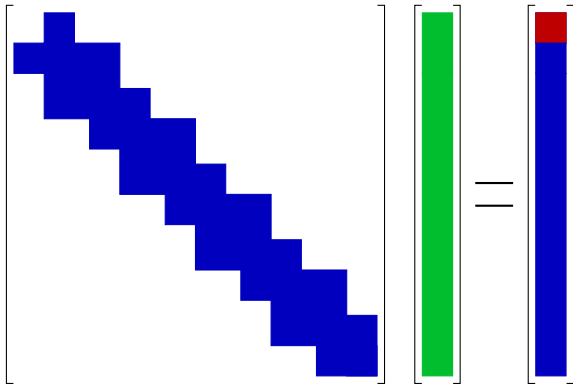
Riccati Recursion



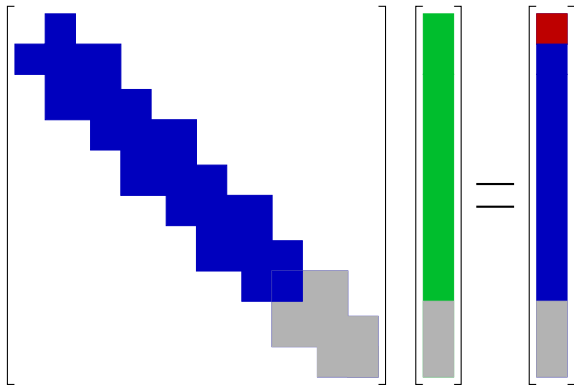
The diagram illustrates the Riccati Recursion equation. It consists of three main components arranged horizontally, separated by an equals sign. The first component is a large square matrix represented by a blue staircase pattern, indicating a sparse structure with non-zero elements along the main diagonal and the first sub-diagonal. The second component is a vertical green rectangle, representing a vector. The third component is a vertical blue rectangle, also representing a vector. The entire equation is enclosed in large square brackets.

$$\begin{bmatrix} \text{Matrix} \end{bmatrix} \begin{bmatrix} \text{Green Vector} \end{bmatrix} = \begin{bmatrix} \text{Blue Vector} \end{bmatrix}$$

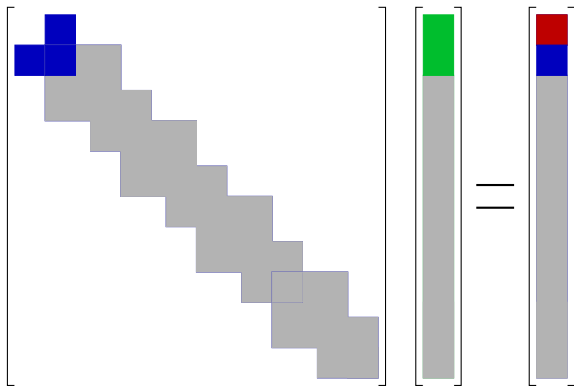
Riccati Recursion



Riccati Recursion

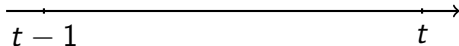


Riccati Recursion



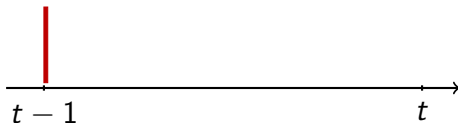
Summary

What happens in interval $[t - 1, t]$?



Summary

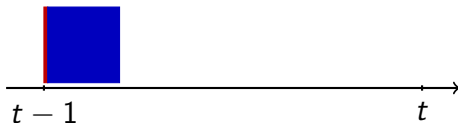
What happens in interval $[t - 1, t]$?



- 1 calculate control u_{t-1} (Riccati Part II)

Summary

What happens in interval $[t-1, t]$?



- 1 calculate control u_{t-1} (Riccati Part II)
- 2 calculate y (Riccati Part II)

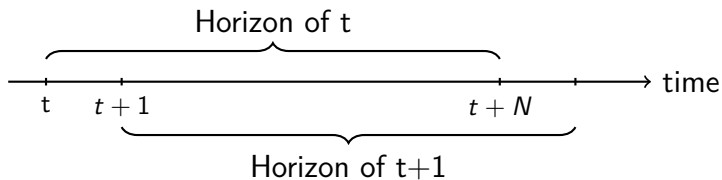
Summary

What happens in interval $[t - 1, t]$?



- 1 calculate control u_{t-1} (Riccati Part II)
- 2 calculate y (Riccati Part II)
- 3 prepare u_t (Newton & Riccati Part I)

Finite Horizon



runtime error

$$N = 20$$

$$N = 50$$

$$N = 100$$

Results