Reactive Anticipatory Robot Skills with Memory

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Motivations

Memory feedback: time-correlations between states

Fast adaptation to changing objectives
Background: System Level Synthesis

Linear Quadratic Regulator (LQR)

\[
\begin{bmatrix}
K^{0,0} & 0 & \cdots & 0 \\
0 & K^{1,1} & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & K^{T,T}
\end{bmatrix}
\begin{bmatrix}
x_0 \\
x_1 \\
\vdots \\
x_T
\end{bmatrix} = \begin{bmatrix}
u_0 \\
u_1 \\
\vdots \\
u_T
\end{bmatrix}
\]

System Level Synthesis (SLS)

\[
\begin{bmatrix}
K^{0,0} & 0 & 0 & \cdots & 0 & 0 \\
K^{-1,0} & K^{1,1} & 0 & \cdots & 0 & 0 \\
\vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
K^{T,0} & K^{T,1} & K^{T,2} & \cdots & K^{T,T-1} & K^{T,T}
\end{bmatrix}
\begin{bmatrix}
x_0 \\
x_1 \\
\vdots \\
x_T
\end{bmatrix} = \begin{bmatrix}
u_0 \\
u_1 \\
\vdots \\
u_T
\end{bmatrix}
\]
Contributions

**extended SLS (eSLS)**
Solves for linear quadratic tracking tasks

**iterative SLS (iSLS)**
Solves for nonlinear nonquadratic tasks

$$u = Kx + k$$

- Memory feedback and time-correlations
- Fast adaptation to changing objectives

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Experimental Results

Even a local controller can exploit memory feedback!
Experimental Results

**Memory feedback and time-correlations**

Even a local controller can exploit memory feedback!

**Fast adaptation to changing objectives**

Local: without resolving the problem

Fast: only a matrix-vector multiplication

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Discussion

\[ u = Kx + k \]

- **Memory feedback and time-correlations**
- **Fast adaptation to changing objectives**

- Learning time-correlations from demonstrations for inverse optimal control

- Increase the validity region of the local controller?

- Time-correlations or independent variations?

- Robustly constrained iSLS

- Warm-starting MPC?