

Optimal Sensor and Actuator Selection in Large-Scale Dynamic Networks

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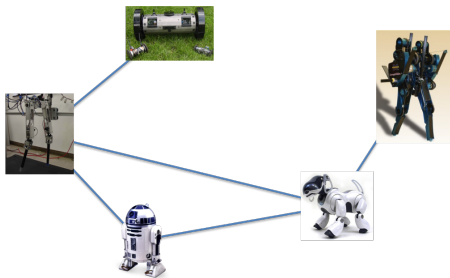


MnDRIVE Kickoff Event; April 17, 2014

Motivation

Challenging in large-scale systems

- ▶ Heterogenous robotic networks
- ▶ Phasor Measurement Units in power networks



Problem Formulation

Linear dynamical system with **many potential actuators**

$$\dot{x} = Ax + B_1 d + B_2 u$$

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Objective: identify **row-sparse** state-feedback controller

$$\begin{array}{ccc} \text{minimize} & J(K) & + & \gamma \sum_i \|e_i^T K\|_2 \\ & \downarrow & & \downarrow \\ & \text{performance} & & \text{row-sparsity-promoting} \\ & \text{index} & & \text{penalty function} \end{array}$$

Challenge: $J(K)$ – **non-convex** function of K

Solution

Change of variables $Y := KX$

- ▶ **Convex dependence** of $J(K)$ on X and Y
- ▶ Row-sparse **structure preserved**

The diagram illustrates the change of variables $Y := KX$. It shows the relationship between vectors u and x , and matrices K , Y , and X^{-1} .

On the left, a vertical vector u is shown as a stack of six colored blocks: white, orange, white, orange, white, orange. To its right is an equals sign, followed by a minus sign, and then a matrix K . The matrix K is a 6x6 grid with the same row-sparse structure as u : white, orange, white, orange, white, orange. To the right of K is a vertical vector x with a single orange block.

Further right is another equals sign, followed by a minus sign, and then a matrix Y . The matrix Y is a 6x6 grid with the same row-sparse structure as K : white, orange, white, orange, white, orange. To the right of Y is a square matrix X^{-1} with a single orange block, followed by a vertical vector x with a single orange block.

Solution

Change of variables $Y := K X$

- ▶ **Convex dependence** of $J(K)$ on X and Y
- ▶ Row-sparse **structure preserved**

$$u = - K x = - Y x^{-1} x$$

Optimization problem

- ▶ **Semidefinite program**

Key contribution

- ▶ **An efficient algorithm for large-scale networks**