Optimization-based control of manipulators

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Optimization-based Control of Robotic Systems

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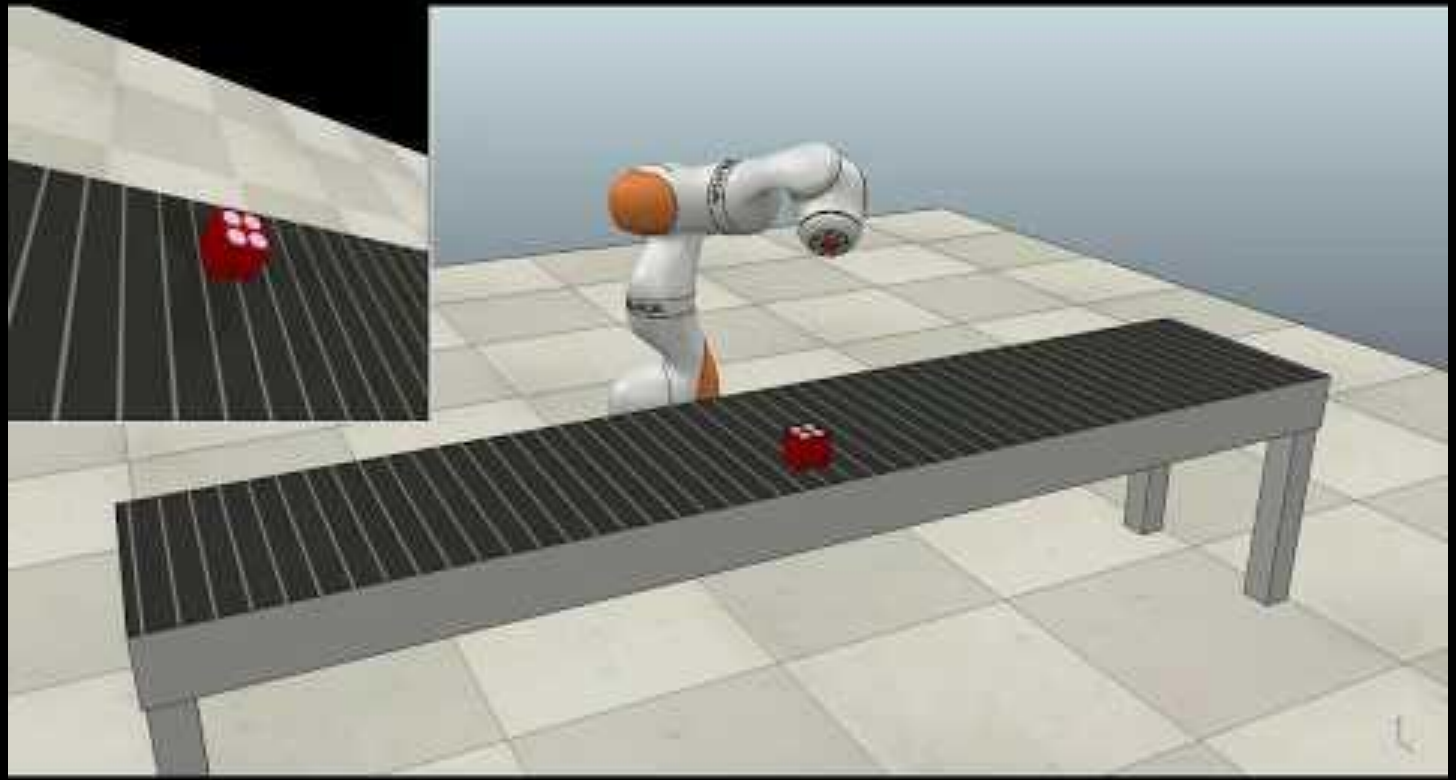
Manipulators



Tasks

- Regulate end effector to a desired pose
- Orient camera to desired point of interest
- Avoid joint limits

Notomista, G., Mayya, S., Selvaggio, M., Santos, M. and Secchi, C., 2020, May. A set-theoretic approach to multi-task execution and prioritization. In *2020 IEEE International Conference on Robotics and Automation (ICRA)* (pp. 9873-9879). IEEE.

Tasks

- Regulate end effector to a desired pose **(stability-like)**
- Orient camera to desired point of interest **(stability-like)**
- Avoid joint limits **(invariance-like)**

Notomista, G., Mayya, S., Selvaggio, M., Santos, M. and Secchi, C., 2020, May. A set-theoretic approach to multi-task execution and prioritization. In *2020 IEEE International Conference on Robotics and Automation (ICRA)* (pp. 9873-9879). IEEE.

Optimization-based formulation

$$\underset{u}{\text{minimize}} \ \|u\|^2$$

$$\text{subject to} \ c_{\text{task},1}(x,u) \leq 0$$

$$\vdots$$

$$c_{\text{task},N}(x,u) \leq 0$$

$L_{f_0}V_1(x) + L_{f_1}V_1(x)u \leq -\alpha_1(V_1(x))$

Stability-like tasks

$L_{f_0}h_1(x) + L_{f_1}h_1(x)u \geq -\alpha_1(h_1(x))$

Invariance-like tasks

Optimization-based formulation

$$\underset{u,\delta}{\text{minimize}} \ \|u\|^2 + \kappa \|\delta\|^2$$

$$\text{subject to } c_{\text{task},1}(x,u) \leq \delta_1$$

$$\vdots$$

$$c_{\text{task},N}(x,u) \leq \delta_N$$

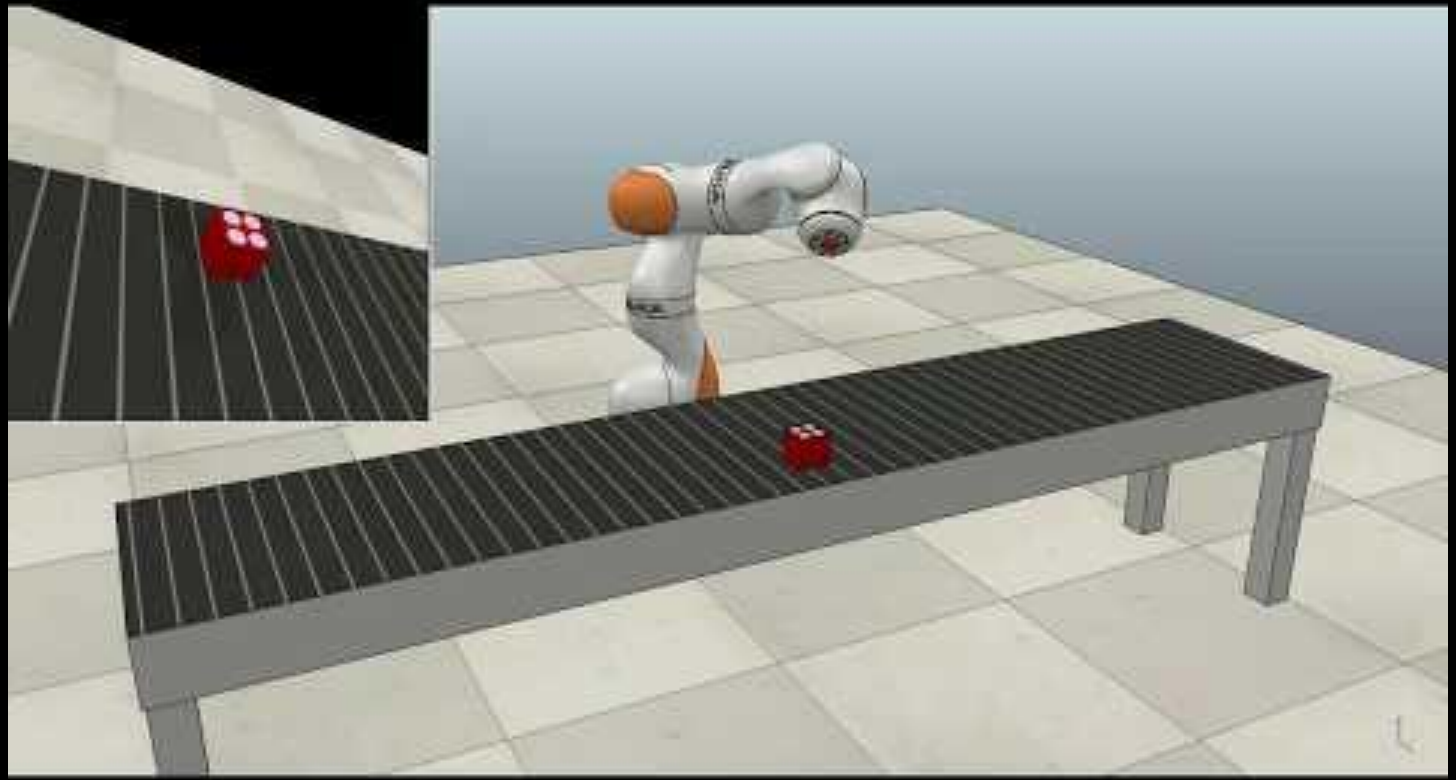
$$K\delta \leq 0$$

Example:

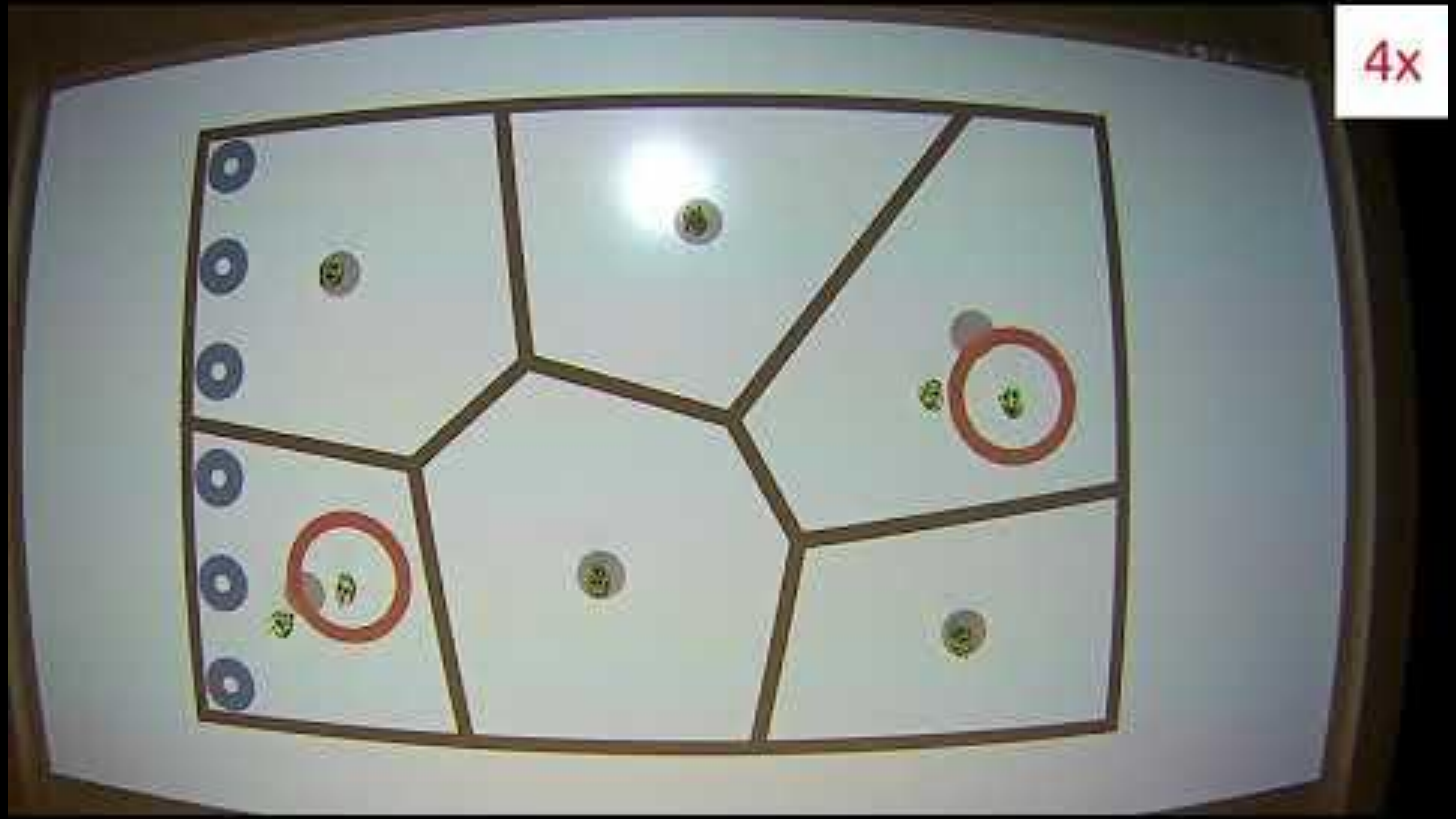
$\delta_1 \leq \delta_2$

task 1 has higher priority than task 2

Priorities between tasks



Mobile robots


4x

Tasks

- Distribute homogeneously over the environment
- Avoid obstacles
- Avoid discharging the battery

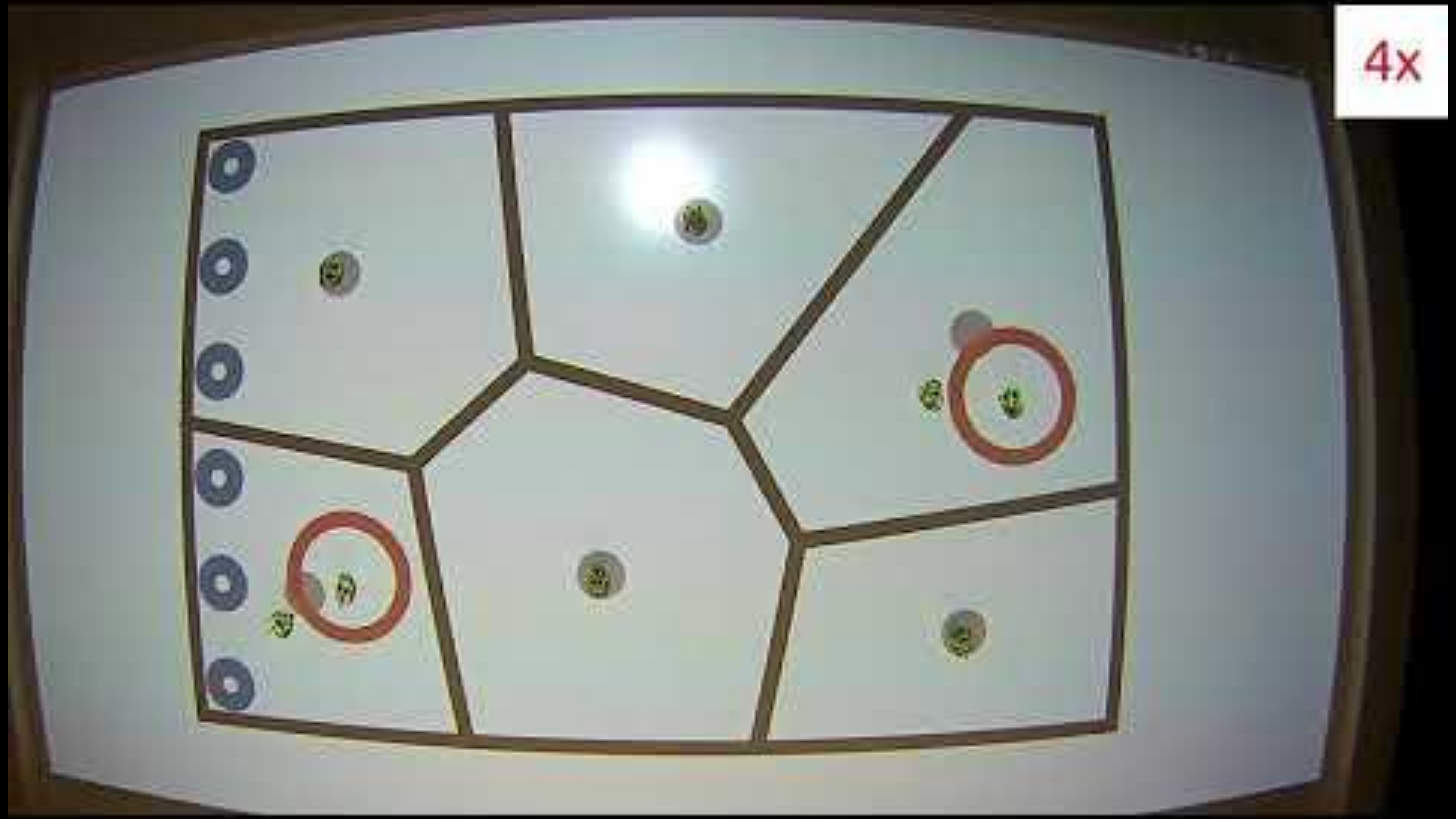
Notomista, G. and Egerstedt, M., 2019, July. Constraint-driven coordinated control of multi-robot systems. In *2019 American Control Conference (ACC)* (pp. 1990-1996). IEEE.

Tasks

- Distribute homogeneously over the environment **(stability-like)**
- Avoid obstacles **(invariance-like)**
- Avoid discharging the battery **(invariance-like)**

`https://github.com/gnotomista/multi_robot_task_allocation`

Notomista, G. and Egerstedt, M., 2019, July. Constraint-driven coordinated control of multi-robot systems. In *2019 American Control Conference (ACC)* (pp. 1990-1996). IEEE.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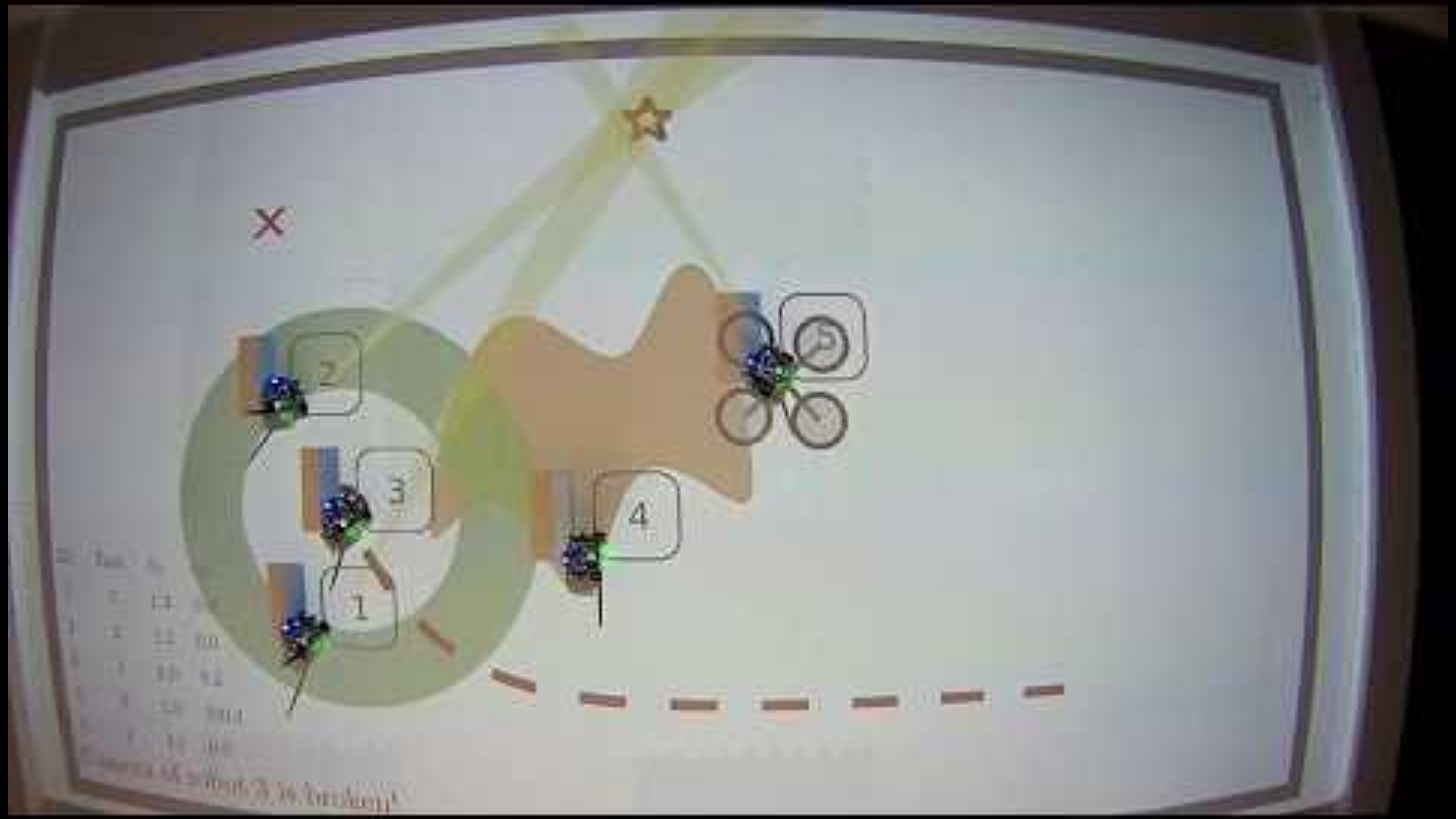
One last example

Notomista, G., Mayya, S., Emam, Y., Kroninger, C., Bohannon, A., Hutchinson, S. and Egerstedt, M., 2021. A resilient and energy-aware task allocation framework for heterogeneous multirobot systems. IEEE Transactions on Robotics, 38(1), pp.159-179.


2
3
4
1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