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Receding Horizon Control of Multiagent Systems with Competitive Dynamics

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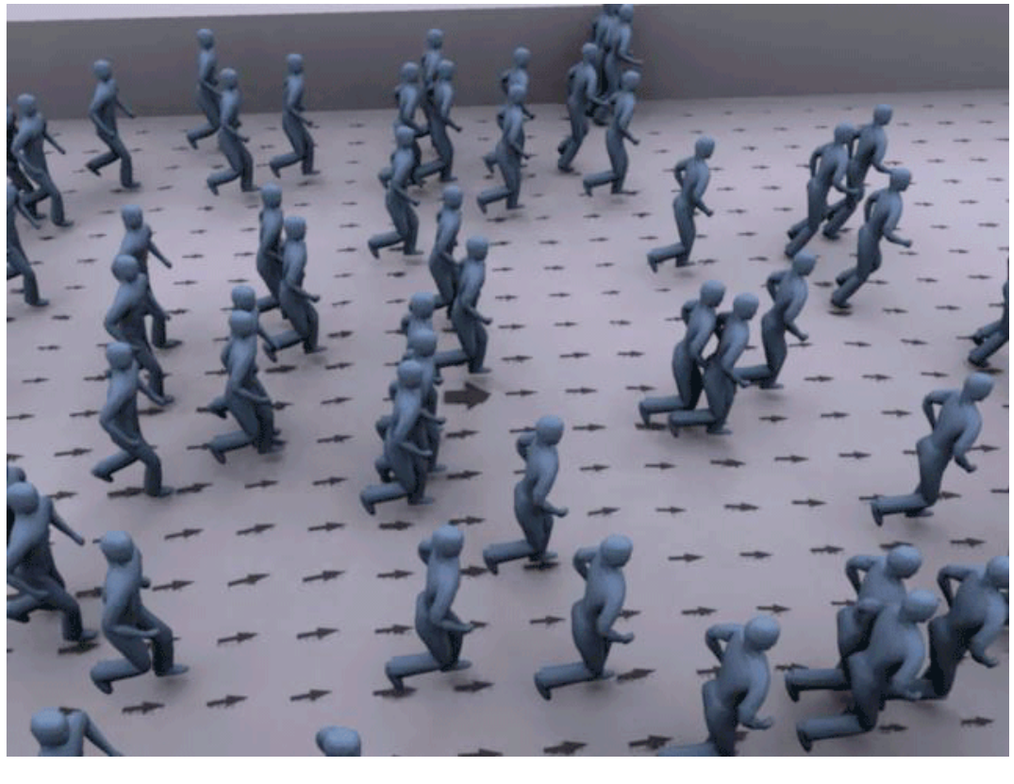
MOTIVATIONS

CIVIL AND MILITARY

CROWD MODELING



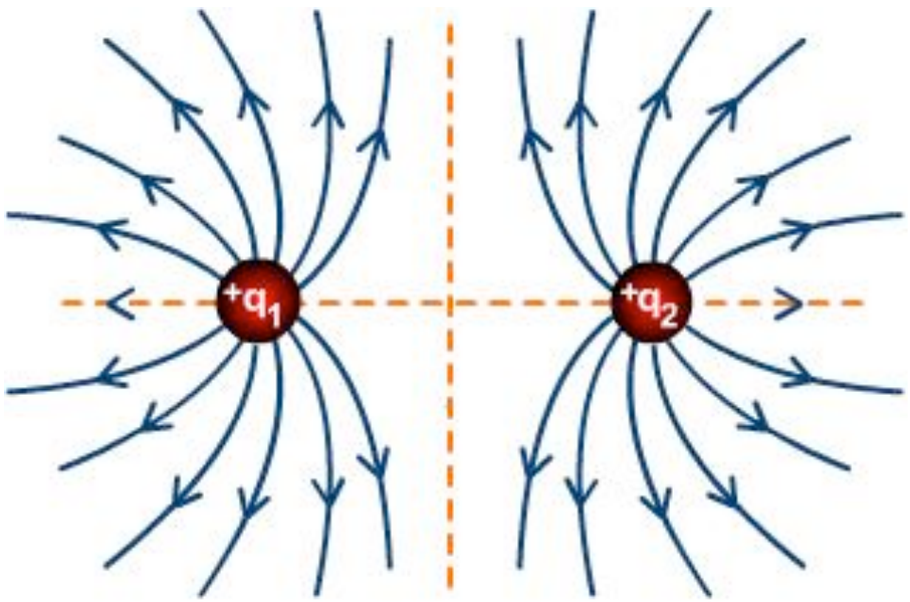
PROJECT OBJECTIVES

RECEDING HORIZON CONTROL or
POTENTIAL-BASED CONTROL?

POTENTIAL:
- Simple
- Effective

RHC:
- Predictive Approach
- Performances Quantification

Flocking Bats - Batman Returns (1992)



Wildbeest Stampede - The Lion King (1994)

CONTRIBUTION

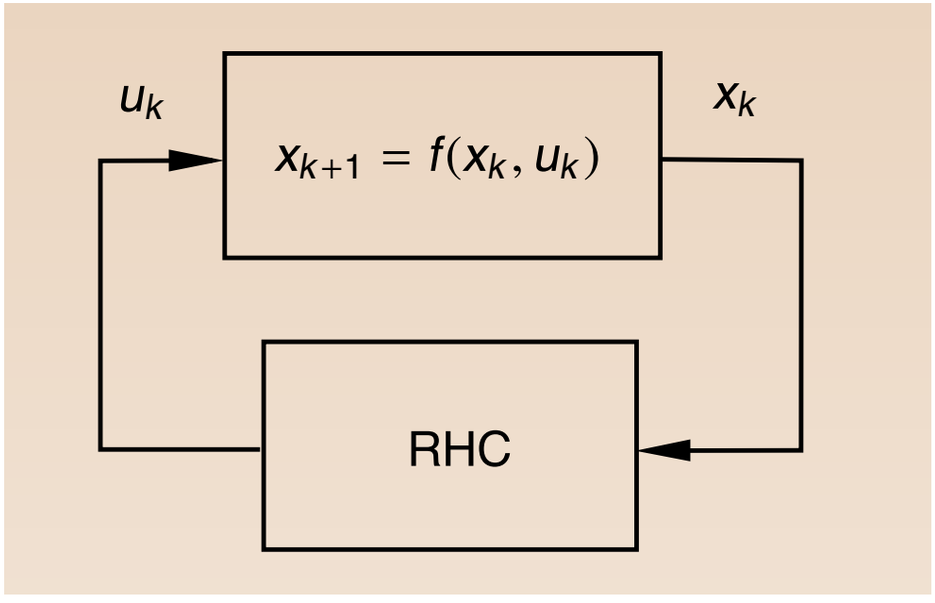
- **RHC MODELING FOR TWO AGENTS** (1 PURSUER, 1 EVADER)
- **PREDICTION**
- **CONTROL**
- **EXPERIMENTAL RESULTS**

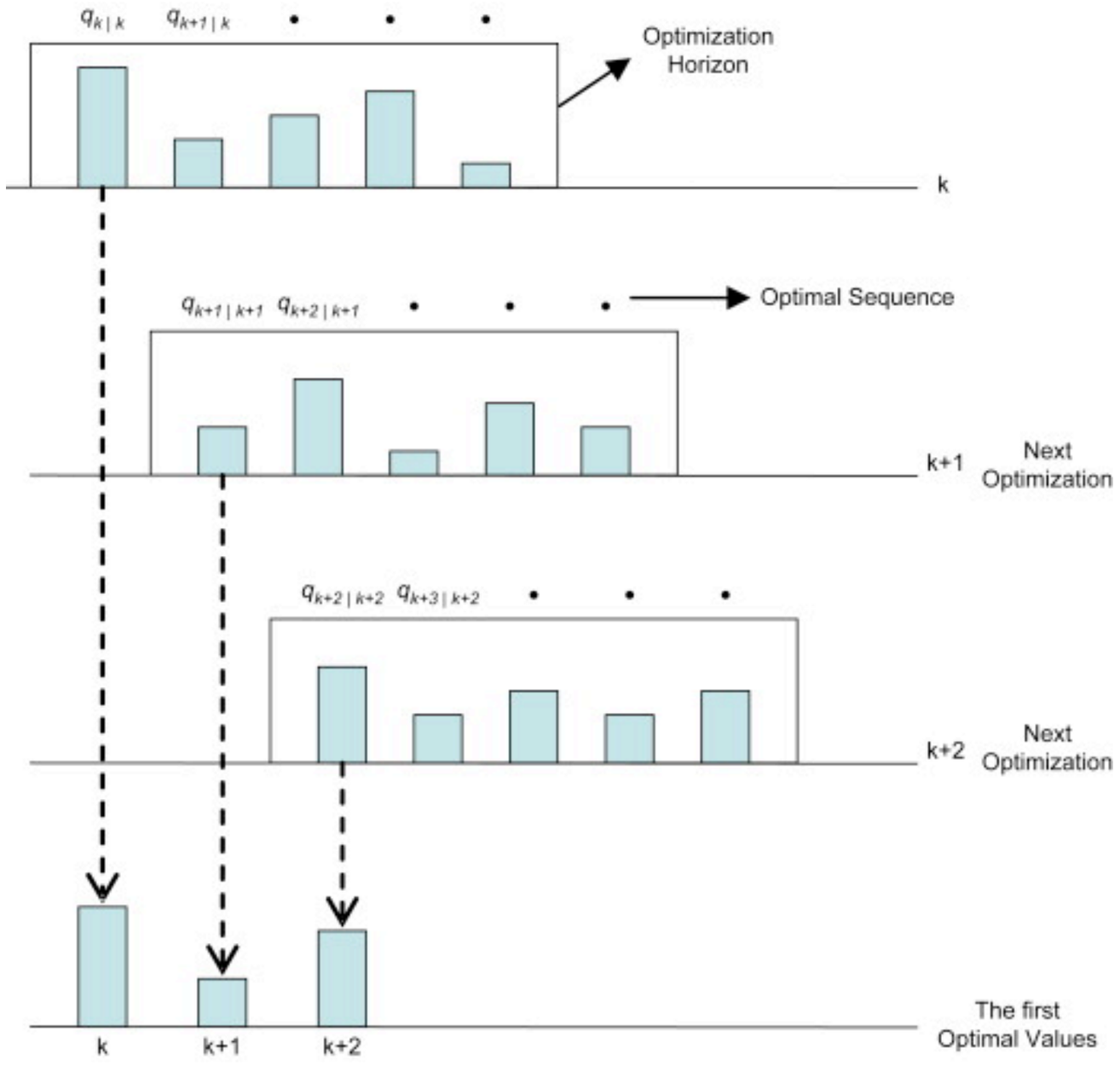
RHC APPROACH

RHC ALGORITHM:

1. Solve an **optimal control problem** over [0, N]
2. $[u_t, u_{t+1}, .., u_{t+N-1}] \rightarrow \mathbf{u_t}$
3. New Measure
4. Go to step

$$J(x,u) = x_N^T S x_N + \sum_{t=0}^{N-1} x_t^T Q x_t + u_t^T R u_t$$





PROBLEM FORMULATION

Agents' dynamics: $s^i_{t+1} = s^i_t + u^i_t, \qquad i = 1, 2,$

Desired Cost Functions: $J_{i,j} = \sum_{k=1}^{N^i-1} (\|s^i_{t+k} - s^j_{t+k} + d^{ij}\|^2_{P^i} + \|u^i_{t+k}\|^2_{R^i}), \qquad i \neq j,$

Used Cost Functions: $J_{i,j} = \sum_{k=1}^{N^i-1} (\|s^i_{t+k} - s^j_t + d^{ij}\|^2_{P^i} + \|u^i_{t+k}\|^2_{R^i}), \qquad i \neq j,$

Control Laws: $u^i_t = \min_{u^i_t, u^i_{t+1}, \ldots, u^i_{t+N}} J_{i,j}(s, u, N)$

$u^j_t = \min_{u^j_t, u^j_{t+1}, \ldots, u^j_{t+N}} J_{j,i}(s, u, N)$

RESULTS

THEOREM: Consider the two agents described by the LTI discrete system, controlled using the RHC strategy, without any state and input constraints. We define the agents distance:

$$e_t^{ij} = x_t^i - x_t^j$$

1) CONTROLLER STRUCTURE: (**Linear** Feedback)

$$u_t^i = \alpha_i(p, r, N)(x_t^j - x_t^i - d_{ij})$$
$$u_t^j = \alpha_j(p, r, N)(x_t^i - x_t^j - d_{ji})$$

A **close form for α** been found, and it depends by p,r (the weight in the cost function) and by the control horizon N. Moreover **α ∈]0,1[**.

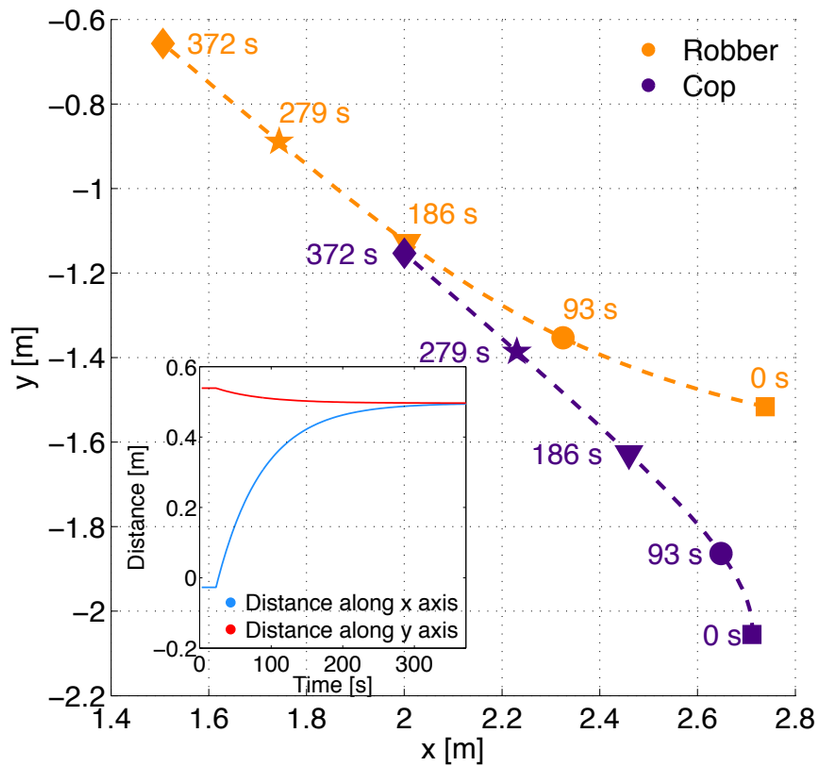
2) STEADY STATE BEHAVIOR: $e^{ij} \longrightarrow \frac{\alpha_j d_{ij} + \alpha_i(-d_{ji})}{\alpha_i + \alpha_j}$

Cooperative: $d_{ij} = -d_{ji} \longrightarrow u_t^i = u_t^j = 0 \longrightarrow$ **Fixed** position

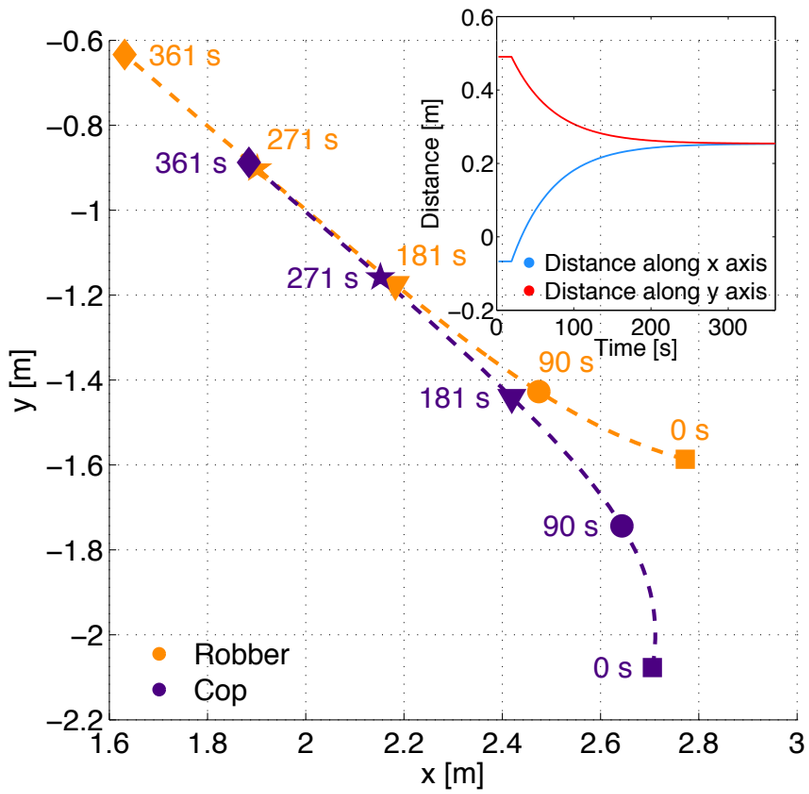
Competitive: $d_{ij} \neq -d_{ji} \longrightarrow u_t^i, u_t^j = cost \longrightarrow$ Convergence along a **line**

SIMULATIONS and EXPERIMENTAL RESULTS

$$J_{i,j} = \sum_{k=1}^{N^i-1} (\|s^i_{t+k} - s^j_t + d^{ij}\|^2_{P^i} + \|u^i_{t+k}\|^2_{R^i}), \qquad i \neq j,$$



Robber Cost Function: R small
Cop Cost Function: R big



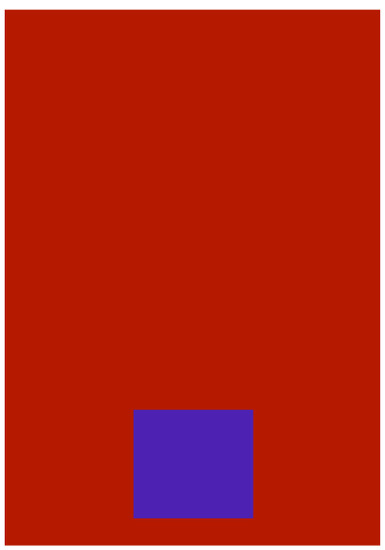
Robber Cost Function: R big
Cop Cost Function: R small

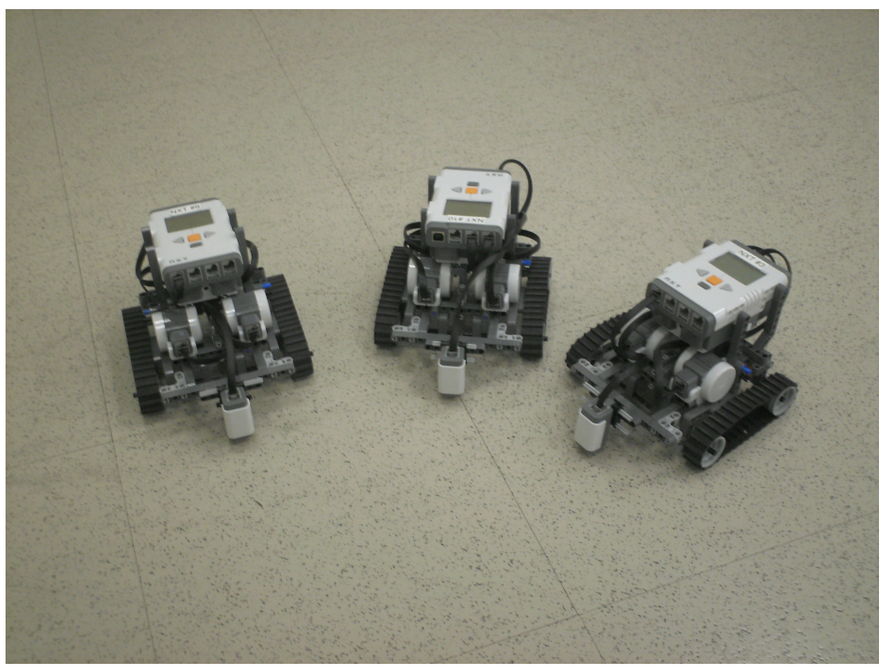
VIDEO FRAMES

PLATFORM

CHARACTERISTIC

- **Robots**: LEGO Mindstorms NXT
- **Control Computer**: MacBook Pro 13″
- **Vision System**: Microsoft LifeCam Studio
- **Communication**: Bluetooth





CONCLUSIONS

RESULTS:

- **Analytic solution** for the pursuit evasion games with RHC.
- **Experimental implementation** and verification of algorithm.

FUTURE RESEARCH:

- Scalability of our results to **larger teams** of agents.
- Inclusion of **estimators** in the algorithms (i.e. use of a ARMA model).