

A Neuro-Genetic Scheme Application for Industrial R³ Workspaces

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Outline

- Introduction
- Adaptive Predictive Control Strategy
- MOGA Reference Generator
- NN Adaptive Predictive Control
- Crane Position Control
- Summary



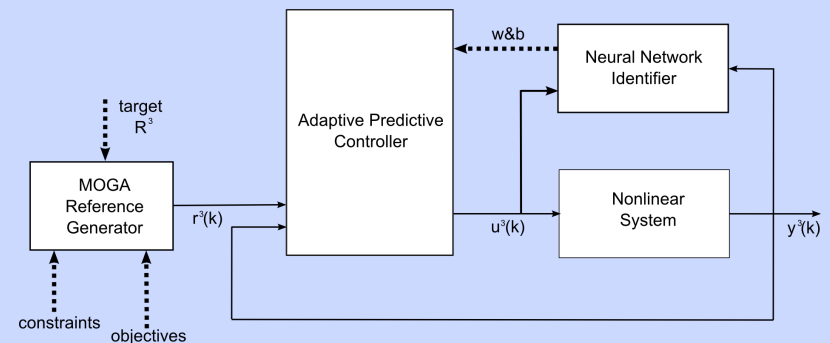
Introduction: Problem Statement

- Effort to transfer Intelligent Control to industry
 - Nonlinear systems control
 - Need to solve real-world complex problems (\mathbb{R}^3 workspaces)

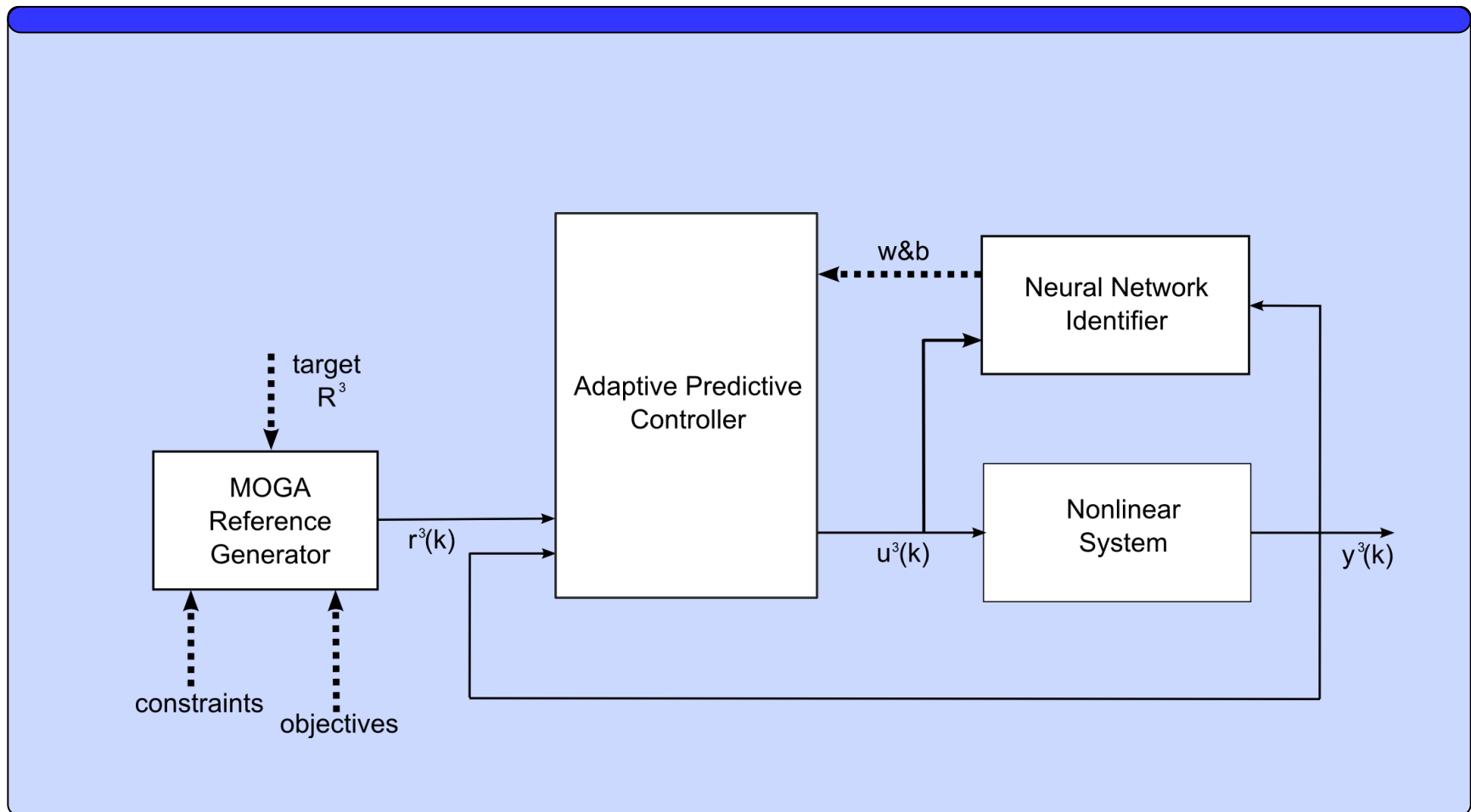


Introduction: A Possible Solution

- Integration of Computational Intelligence in the control strategy
 - Genetic Algorithms for trajectory generation
 - Neural Networks for reference tracking

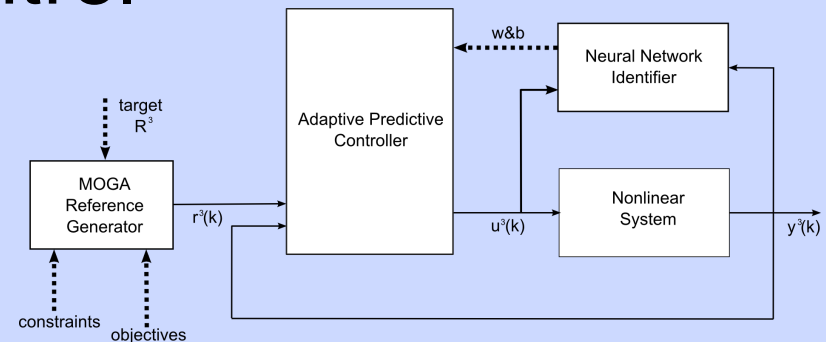


Adaptive Predictive Control Strategy



Adaptive Predictive Control Strategy

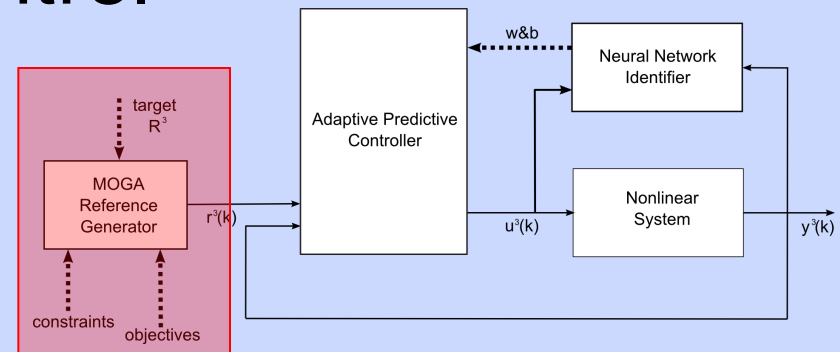
- Reference generation
- Neural Network online training
- Nonlinear system identification
- Nonlinear system control



Adaptive Predictive Control Strategy

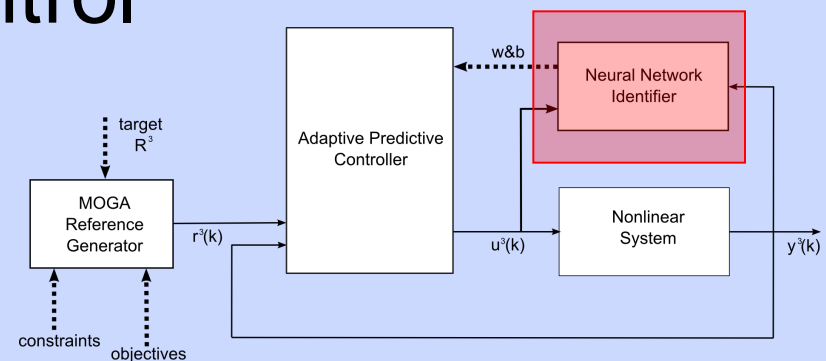
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- **Reference generation**
- Neural Network online training
- Nonlinear system identification
- Nonlinear system control



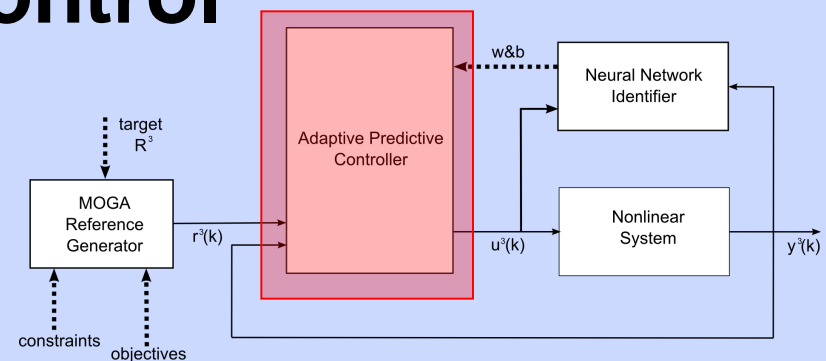
Adaptive Predictive Control Strategy

- Reference generation
- *Neural Network online training*
- **Nonlinear system identification**
- Nonlinear system control

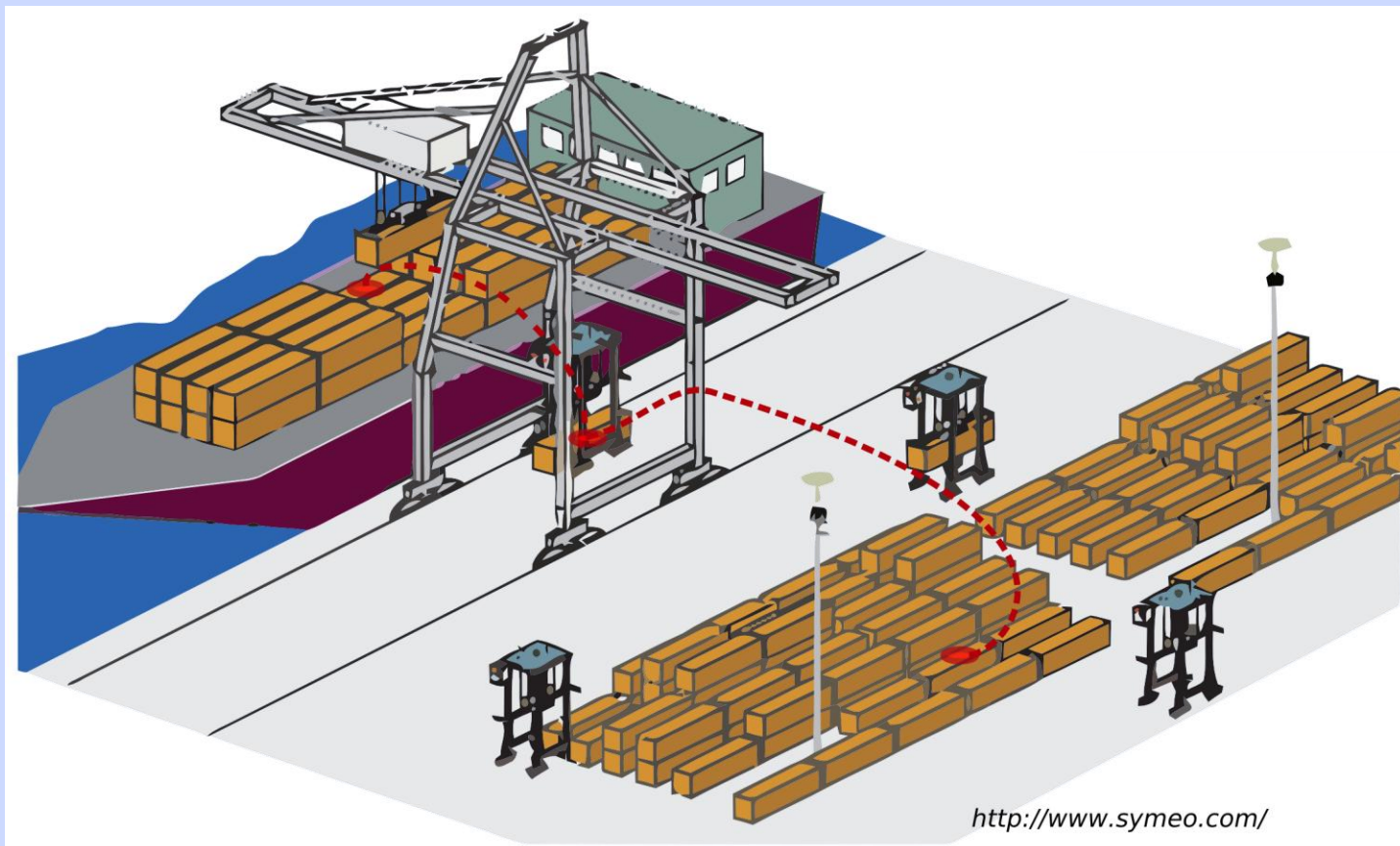


Adaptive Predictive Control Strategy

- Reference generation
- *Neural Network online training*
- Nonlinear system identification
- **Nonlinear system control**

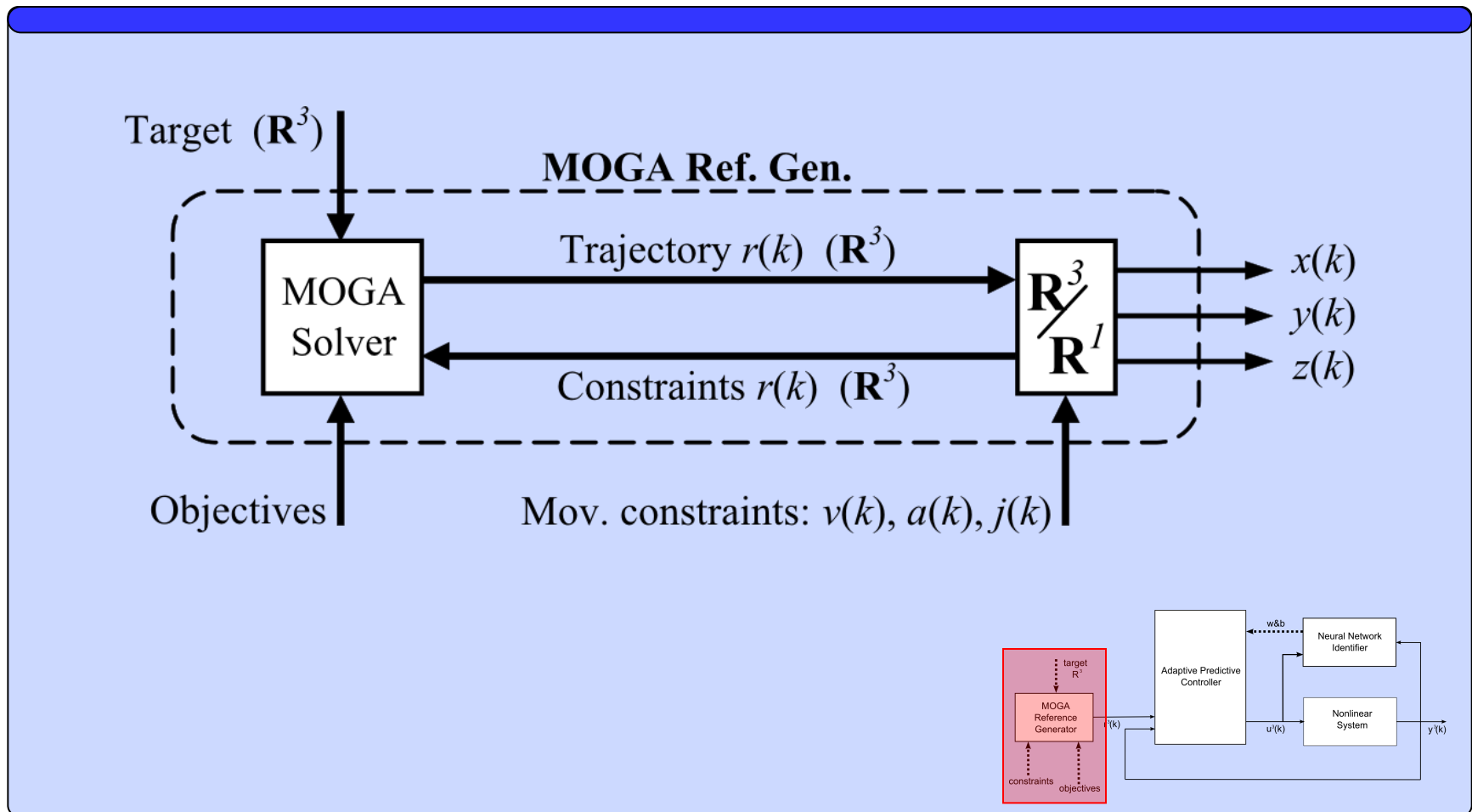


MOGA Reference Generator



MOGA Reference Generator


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MOGA Reference Generator

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Optimization Problem Formulation

Trajectory to search: 
 $(x_0, y_0, z_0) \rightarrow (x_f, y_f, z_f)$

Constraints:

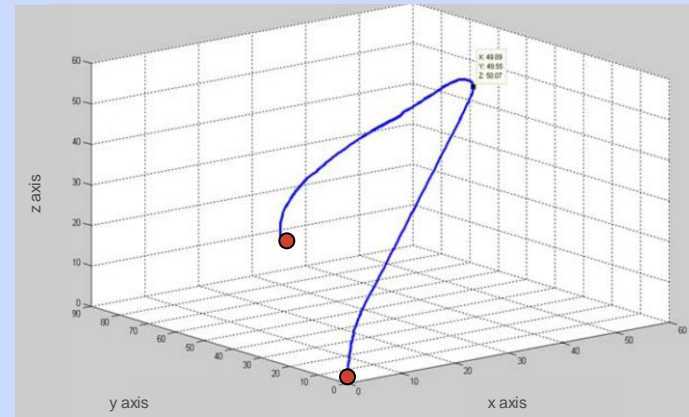
$$\ddot{x}(t) \leq A_x \quad \ddot{y}(t) \leq A_y \quad \ddot{z}(t) \leq A_z$$

$$\dddot{x}(t) \leq G_x \quad \dddot{y}(t) \leq G_y \quad \dddot{z}(t) \leq G_z$$

$$z_p = f_3(x, y)$$

Objectives:

$$\min \begin{cases} E_s = \sqrt{(x_f - x_0)^2 + (y_f - y_0)^2 + (z_f - z_0)^2} \\ - \int_0^{t_f} \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \left(\frac{dz}{dt}\right)^2} dt \\ t_f = \max(t_{6x, 6y, 6z}) \\ e = \sqrt{(x_f - x_0)^2 + (y_f - y_0)^2 + (z_f - z_0)^2} \\ E_{dp} = \sqrt{(x_i - x_p)^2 + (y_i - y_p)^2 + (z_i - z_p)^2} \end{cases}$$

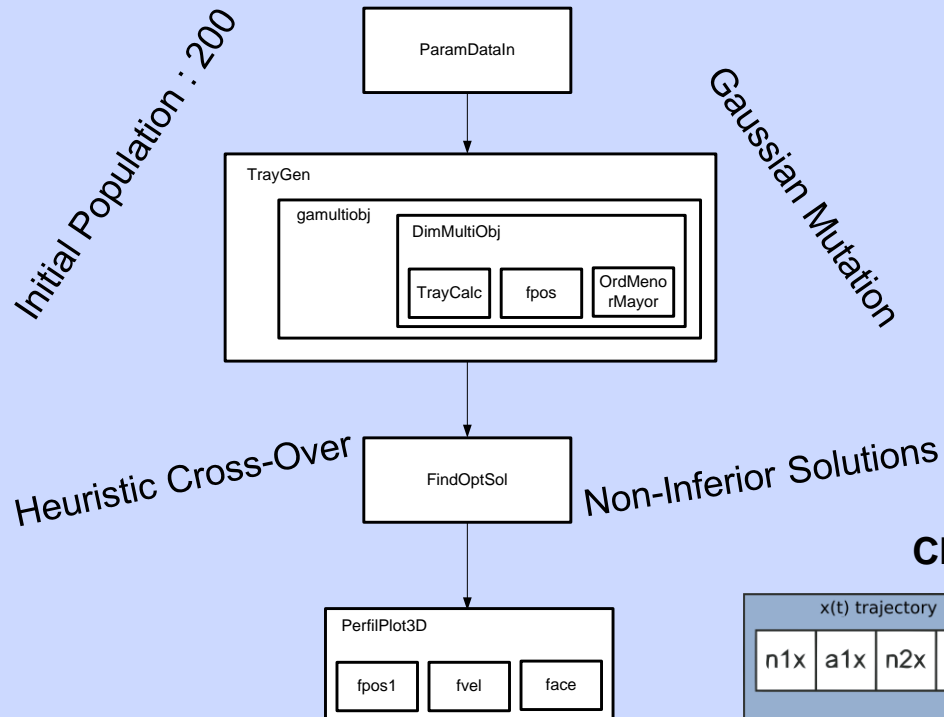


MOGA Reference Generator

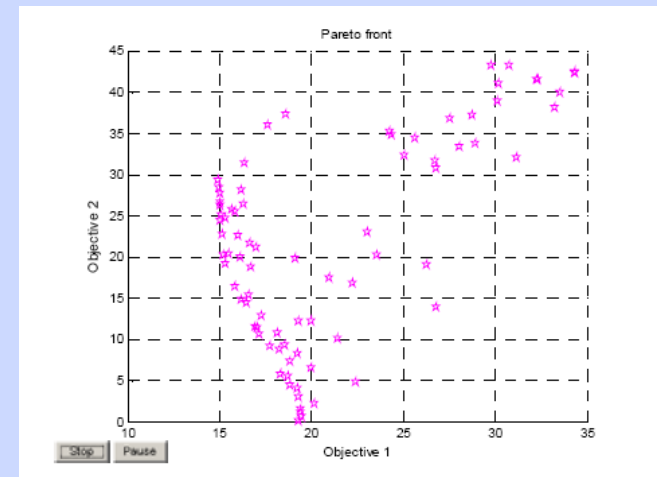
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Solution:

Multiobjective Genetic Algorithm non-linear searching method.



Pareto Front

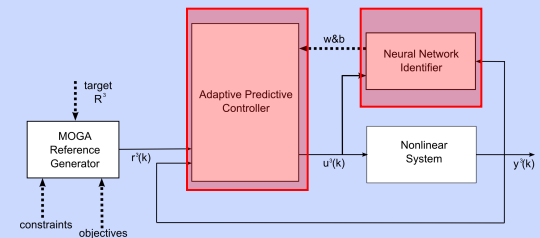


Chromosome= 15 variables (gens)

x(t) trajectory				y(t) trajectory				z(t) trajectory				overshoot		
n1x	a1x	n2x	a2x	n1y	a1y	n2y	a2y	n1z	a1z	n2z	a2z	pbx	pby	pbz

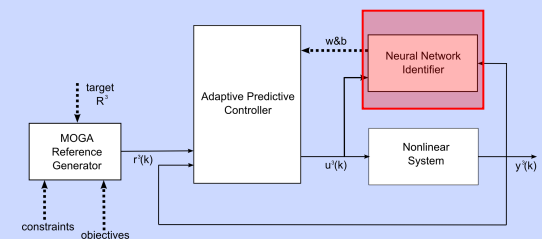
NN Adaptive Predictive Control

- NN Control:
 - Complex nonlinear controllers
- NN Identification:
 - Universal approximators



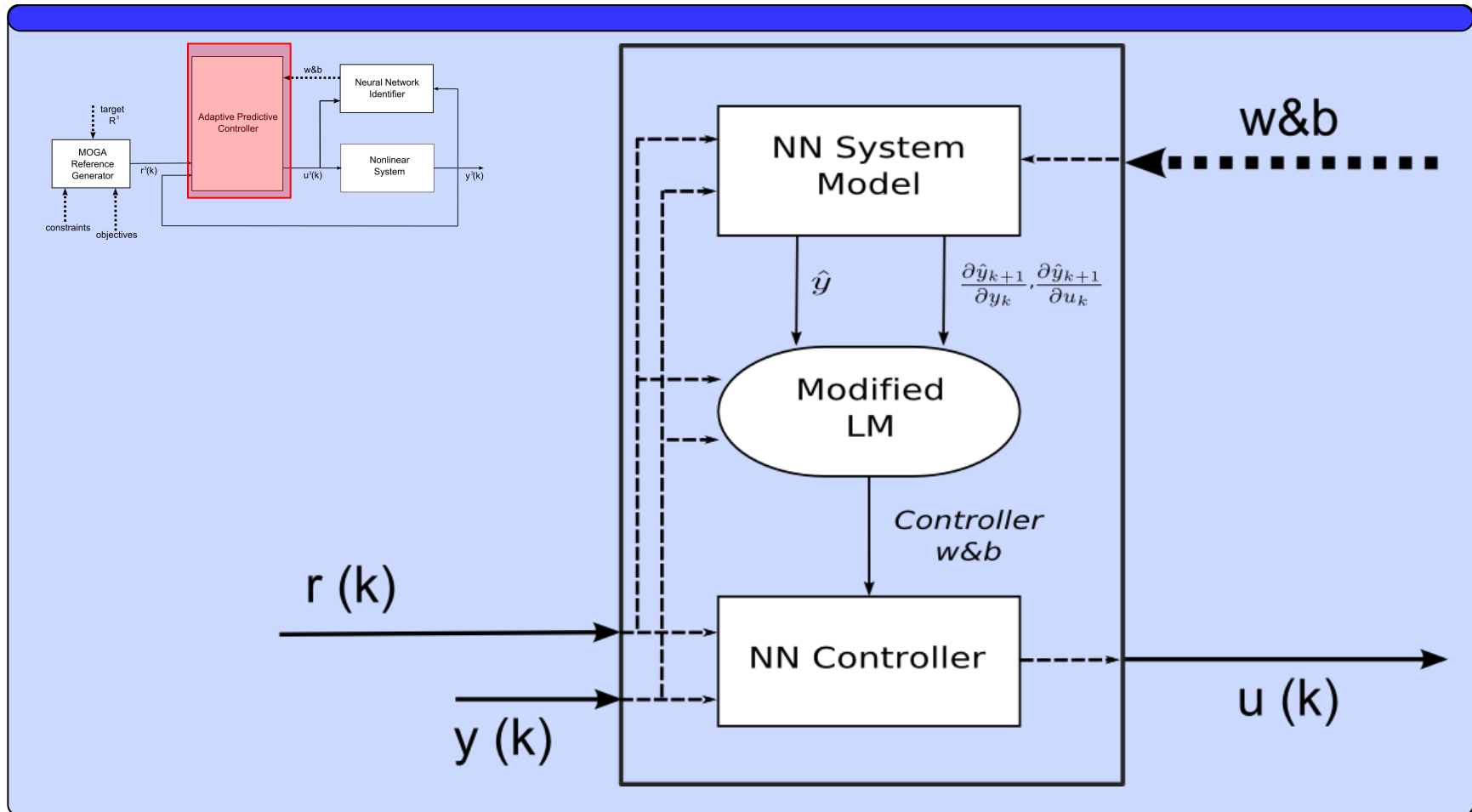
NN Adaptive Predictive Control

- Neural Network Identifier provides:
 - System output estimation.
 - System derivatives estimation.



NN Adaptive Predictive Control

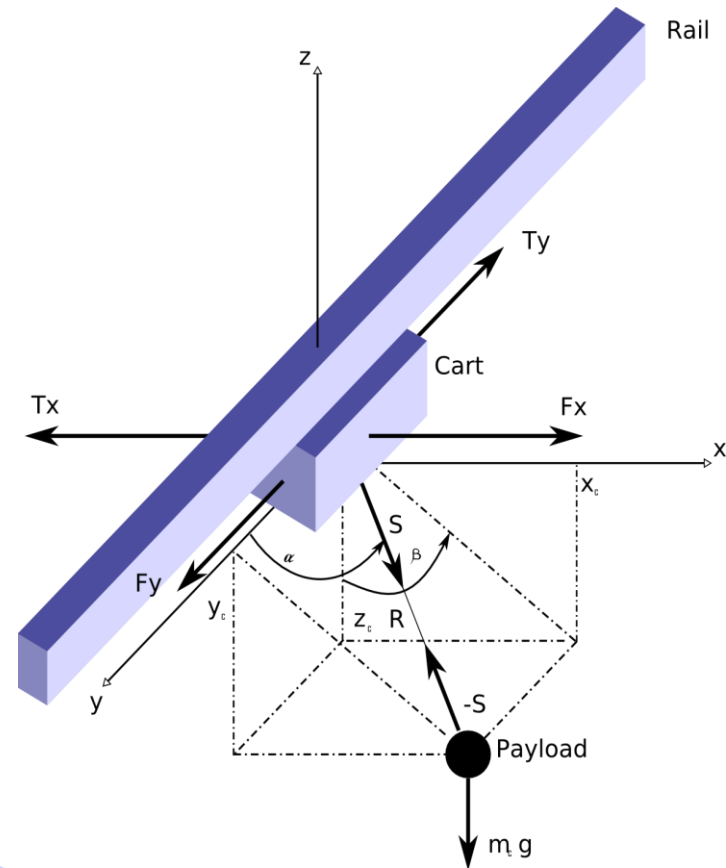
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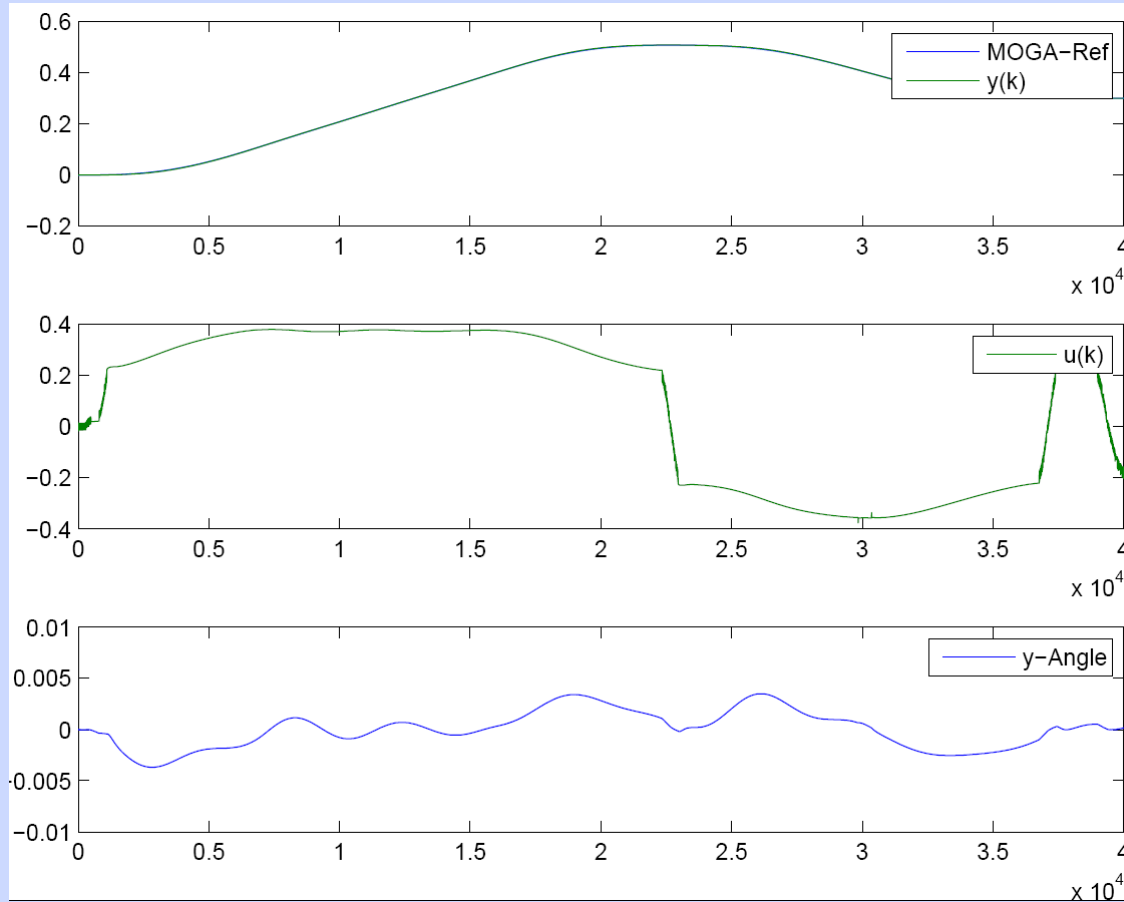
Crane Position Control

- Crane model
- Trajectory pos.

$(x_0, y_0, z_0) \rightarrow (x_f, y_f, z_f)$



Crane Position Control



Summary

- Trajectory generation & tracking.
 - Multi Objective Genetic Algorithm.
 - Neural Network.
- Future work...
 - Real crane prototype.



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THANK YOU
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